Policies for Promotion of Renewable Energy in China and India

Report of Work Package 3

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1. Introduction

Present levels of sulfur deposition resulting from the use of fossil fuels are estimated to exceed the sustainable 'no damage' levels for a range of ecosystems in large parts of Asia. Countries have embarked on costly strategies to reduce their emissions of SO_2. Following examples from Europe and North America, most of these policies focus on technical means to control SO_2 emissions.

Renewable energy offers a certain potential for substituting sulfur containing fuels and thereby constitute an additional option for reducing SO_2 emissions in Asia.

Financially supported by the INCO programme of the European Union, a team of Asian and European researchers initiated a study on the 'Potential for Use of Renewable Sources of Energy in Asia and their Cost-Effectiveness in Air Pollution Abatement'. The project aims to identify the potential for cost-effective emission controls offered by enhanced utilization of renewable energy in Asia. The first two work packages of the project systematically compiled a detailed inventory on the potential for renewable energy in India and China and developed a methodology to assess the cost-effectiveness of an enhanced use of renewable energy to control sulfur emissions in Asia. The objective of the third work package was to identify potentially policy relevant conclusions from the modeling exercise, to confront them with the present practices of promoting renewable energy in India and China and to communicate the lessons drawn from the exercise to experts in these two Asian countries.

Two workshops were hold in India (hosted by the TATA Energy Research Institute, New Delhi, December 1998) and in China (hosted by the Chinese Energy Research Institute, Beijing, May 2000), at which the study and the developed assessment tools were presented to national experts. In discussions with local planners at these workshops relevant policy conclusions were developed, which provided the basis of the analysis presented in this report. The proceedings of the first workshop were published by the TATA Energy Research Institute (TERI, 1998), while the discussions of the Beijing workshop are reflected in this report.

Section 2 of this report summarizes the findings of Work Package 1 about the estimated potential for renewable energy in India and China and of Work Package 2, which identified the potential contribution of renewable energy to cost-effective emission control strategies in Asian countries. Section 3 reviews present policies to promote renewable energy in India and China and compares them with policy instruments applied in IEA countries to foster an enhanced utilization of renewable energy in industrialized countries. Practical policy implications of the findings of the model study and of the country reviews are presented in Section 4.

2. The Potential of Renewable Energy for Cost-effective SO_2 Controls in India and China

Section 2 of this report provides a brief summary of the results of Work Package 1 and Work Package 2 and how they have been derived. While details are given in the final reports of the respective work packages (TERI *et al.*, 1999; Boudri *et al.*, 2000a) and in a series of journal articles (Amann *et al.*, 2000; Boudri *et al.*, 2000b, Li Junfen *et al.*, 2000; Panwar *et al.*, 2000) the main findings are summarized in this paper so that the reader can compare the conclusions suggested by the model analysis with present policy practice in India and China (Section 3).

2.1. Methodology

This project aims to identify the potential for cost-effective emission controls offered by enhanced utilization of renewable energy in Asia. In a first step, work identified the likely penetration of renewable energy in China and India as seen by the national experts from these countries, and explored the maximum potential for renewable energy that could be utilized through focused policy measures.

Using the 'business as usual' energy projections, the project estimated in a second step the likely development of SO_2 emissions in these two countries, taking into account, *inter alia,* the presently decided legislation on emission controls.

Based on these emission projections, the third step explored the development of regional sulfur deposition up to the year 2020 and compared it with the sustainable levels of sulfur deposition that are believed not to cause damage to ecosystems (the critical loads). It is found that in large parts of Asia sulfur deposition is expected to exceed these critical loads to a significant extent.

In a fourth step, the study established several hypothetical environmental objectives in China and India (in terms of sulfur deposition) and explored cost-effective ways of reducing the emissions of $S0_2$ in the year 2020 in such a way so that these objectives are met. For this purpose the study developed and applied an optimization module to identify the least-cost combination of emission control measures in the various regions of Asia. This optimization takes into account differences in the available emission control potential, the costs for reducing SO_2 emissions in the different regions in Asia, the differences in environmental sensitivities and the characteristic dispersion behavior of sulfur in the atmosphere. The analysis was first conducted for the business as usual energy projection and identified the cost-optimal allocation of technical SO_2 control measures.

In a fifth step, the study repeated the above analysis, however with the difference that also the potential for (and costs of) SO_2 reductions offered by an increased penetration of renewable energy was taken into account.

2.2. The Potential for Use of Renewable Energy

2.2.1. China

An updated projection of the use of conventional fuels for China was supplied by the Chinese Energy Research Institute (ERI, 2000). Reflecting the latest view on the economic development of China which assumes for 2020 a 25 percent growth of population and a five-fold increase in GDP, total primary energy demand is expected to increase by 47 percent compared to 1995 or by 125 percent, if related to 1990. Thereby, the energy demand anticipated for 2020 is now about 25 percent lower than it was projected in the early 1990s.

In the "Business as Usual" (BAU) scenario the use of biomass is expected to decline by about 22 percent (compared to 1995), and even the "Policy" (POL) scenario foresees seven percent less biomass use (due to resource constraints). Other renewable energy sources (hydropower, wind, etc.) will triple their contribution even in the BAU scenario and will thereby lead to a higher overall consumption of renewable energy (+30 percent in the BAU case and +70 percent in the policy scenario).

This increase in renewable energy could make it possible to reduce the growth in coal consumption, which could slow from a 52 percent increase in the BAU case to a 38 percent growth in the policy case. Consequently, there would also be less CO_2 emissions in the policy case, however still 63 percent more than in 1995.

2.2.2. India

For India, the TATA Energy Research Institute (TERI) provided a projection of conventional energy demand in aggregated form (TERI, 1999). On the basis of a 40 percent increase in population accompanied by a quadrupling of GDP, total primary energy demand is expected to double until 2020. In the business as usual case renewable energy use would stay constant; the decline in biomass use would be compensated by other forms of renewable energy. A policy scenario, however, sees the potential for a 50 percent increase of renewable energy, which could then reduce the expected increase in coal consumption by almost 50 percent. As a further consequence, the policy scenario would see a 150 percent increase in CO_2 emissions, while for the business as usual scenario a 200 percent growth must be anticipated.

2.3. The Role of Renewable Energy in SO_2 Control

2.3.1. Sulfur Emissions in Asia

Table 2.1 presents for the above mentioned cases aggregated results for China and India, while sector- and fuel-specific results are provided in Table 2.2 (China) and Table 2.3 (India). Both in China and India emissions of SO_2 increased during the five years between 1990 and 1995 by 15 and 35 percent, respectively. For the future, the further development crucially depends on the measures taken to control emissions.

Table 2.1 Comparison of SO_2 emission scenarios for China and India, million tons

			2020	
Country	1990	1995	BAU_NOC	POL_NOC
China	20.8	23.9	36.6	33.7
India	3.7	5.0	13.0	10.5
Total	**24.5**	**28.9**	**49.6**	**44.2**

	2020			
Country	BAU_CLE	POL_CLE	BAU_MFR	POL_MFR
China	29.6	28.2	6.1	5.8
India	12.3	9.9	2.0	1.9
Total	**41.9**	**38.1**	**8.1**	**7.7**

For the business as usual energy projection, Chinese SO_2 emissions could theoretically increase by more than 50 percent if no measures were taken to control emissions (the "No Control"- NOC case). However, China has adopted recently stringent emission standards to restrict the release of SO_2

emissions, so that the analysis would only suggest a further increase by 23 percent compared to 1995. Theoretically, full application of available emission control technologies could cut SO_2 emissions by more than 75 percent compared to 1995.

For India the analysis suggests for the "no control" case SO_2 emissions to grow by about 160 percent above the 1995 level. With the measures recently adopted by national legislation, the increase is expected to be somewhat lower (146 percent), while theoretically on a technical basis SO_2 emissions could be reduced by up to 60 percent.

Renewable energy has a certain potential to substitute sulfur-containing fuels. For a "no control" case, the maximum use of renewable energy (the "policy" scenario - POL) results for China in about nine percent less SO_2 emissions and for India in 19 percent less sulfur emissions. It is interesting to note that for India a "maximum renewable energy" scenario results in significantly lower sulfur emissions than what is expected from the presently decided technical emission control measures.

The most important source of unabated emissions in both countries is coal combustion (compare Table 2.2 and Table 2.3). The share of emissions from coal in 2020 is 95 percent in China and 62 percent in India.

Table 2.2; Emissions of SO_2 by fuel for China, uncontrolled cases (million tons)

			Business as usual, No control			Policy scenario, No control		
Fuel	1990	1995	2000	2010	2020	2000	2010	2020
Coal	19.7	22.6	26.8	30.7	34.7	26.5	29.0	30.9
Oil	0.5	0.6	0.8	0.9	1.0	0.7	0.9	1.0
Biomass	0.5	0.6	0.5	0.5	0.5	0.5	0.8	1.2
Other	0.1	0.2	0.2	0.3	0.4	0.2	0.4	0.6
Total	**20.8**	**23.9**	**28.3**	**32.4**	**36.7**	**28.0**	**31.0**	**33.7**

Table 2.3: Emissions of SO_2 by fuel for India, uncontrolled cases (million tons)

			Business as usual, No control			Policy scenario, No control		
Fuel	1990	1995	2000	2010	2020	2000	2010	2020
Coal	2.3	3.2	3.8	5.5	8.1	3.1	3.8	5.7
Oil	1.2	1.4	1.8	2.7	4.4	1.8	2.7	4.3
Biomass	0.2	0.3	0.2	0.2	0.2	0.2	0.2	0.2
Other	0.1	0.1	0.1	0.2	0.3	0.1	0.2	0.3
Total	**3.7**	**5.0**	**6.0**	**8.6**	**13.0**	**5.2**	**6.9**	**10.5**

Figure 2.1 displays the sulfur dioxide emission density in China and India in 1995. In China, emissions in Shanghai and in the Sichuan province exceeded more than 400 kilotons per grid cell, while in India estimated emission densities were everywhere below 150 kilotons per grid cell.

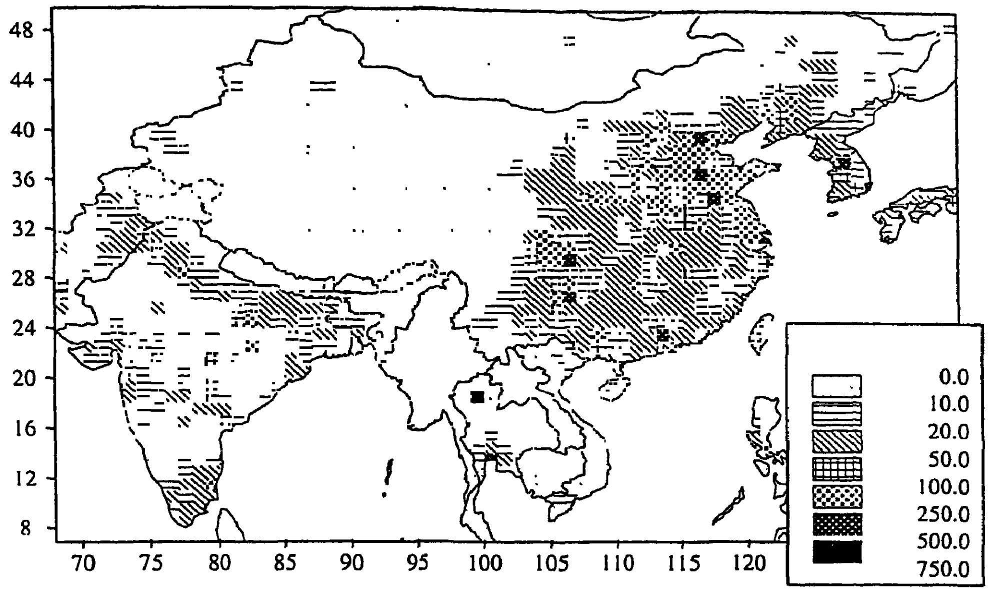

Figure 2.1: SO_2 emissions in 1995 (in tons per grid cell)

2.3.2. Present and Future Deposition of Sulfur in Asia

Figure 2.2 and Figure 2.3 compare the spatial distribution of sulfur deposition in India and China for 1990 and 2020 for the "current legislation - business as usual" scenario. In 1990 in China, sulfur deposition exceeded 5-g S/m^2/year in Sichuan and in the Jiangsu provinces, while in Chongquing sulfur deposition peaked at more than 10 g S/m^2/year. In India deposition levels below 0.5 g S/m^2/year prevailed over large parts of the country, with few hot spots which however did not exceed 2 g S/m^2/year.

The analysis suggests that until 2020 sulfur deposition will generally increase in both countries. Over large areas of South-east China deposition would increase to 2 - 5 g S/m^2/year. However, because of the controls applied in the current legislation scenario on the most polluting sources in the power plant sector, even in the hot spot areas in Tianjin, Sichuan, and Jiangsu sulfur deposition will remain at a level of 5 - 7 g S/m^2/year. In India deposition will increase to 1 - 2 g S/m^2/year with peaks in the hot spots below 5 g S/m^2/year.

Figure 2.4 displays for 1990 sulfur deposition exceeding the 25 percentile critical load, i.e., how much sulfur deposition is above the level that protects 75 percent of the ecosystems. In India sulfur deposition was calculated to exceed the 25 percentile critical load only at two grid cells, while excess deposition was a common phenomenon in large areas of southeastern China. In the hot spot areas of China, excess deposition reached more than 5000 acid eq/ha/year[1].

Even with present legislation (the current legislation - business as usual scenario), calculations suggest that the situation will deteriorate in 2020 (Figure 2.5). Excess deposition is expected to further grow in Guangzhou, Guandong, Hainan, Hunan, Shandong and in Zheijang. However, the peak values will remain below 5000 acid eq/ha/year.

For India, excess deposition is expected for the current legislation scenario for 2020 in Bihar, Bengal, Utar Pradesh and along the sea coast, but in most areas excess deposition will stay below 500 acid eq/ha/yr. Larger exceedances (up to 1000 acid eq/ha/year) occur only in less than ten hot spots.

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[1] 1000 acid equivalents/ha/year is equal to 1.6 g sulfur/m^2/year.

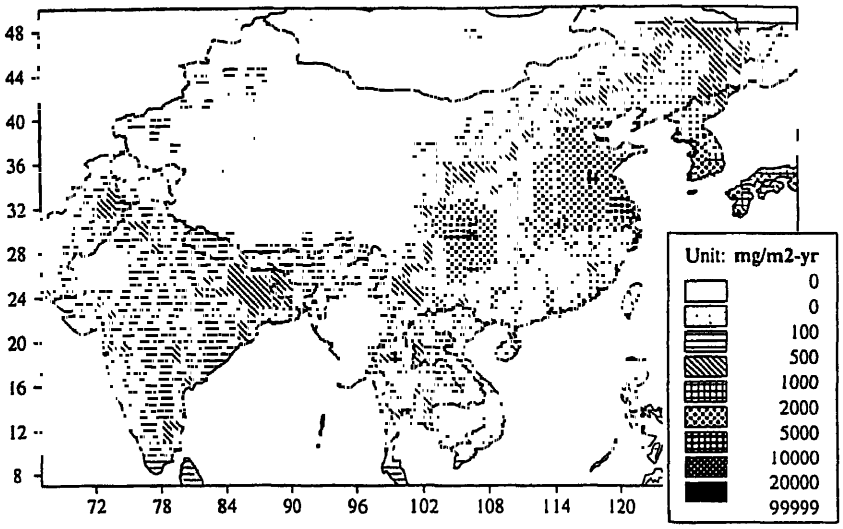

Figure 2.2: Sulfur deposition 1990 (mg S/m^2/year)

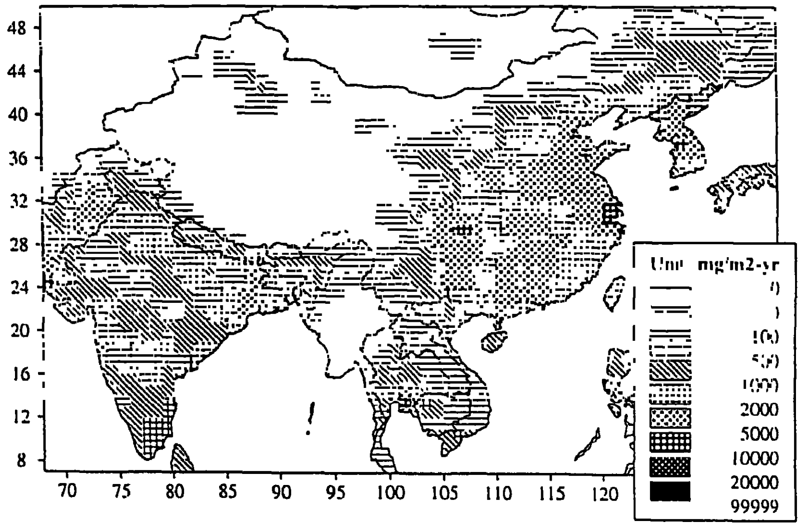

Figure 2.3: Sulfur deposition for the "current legislation - business as usual" (BAU-CLE) scenario in 2020 (mg S/m2/year)

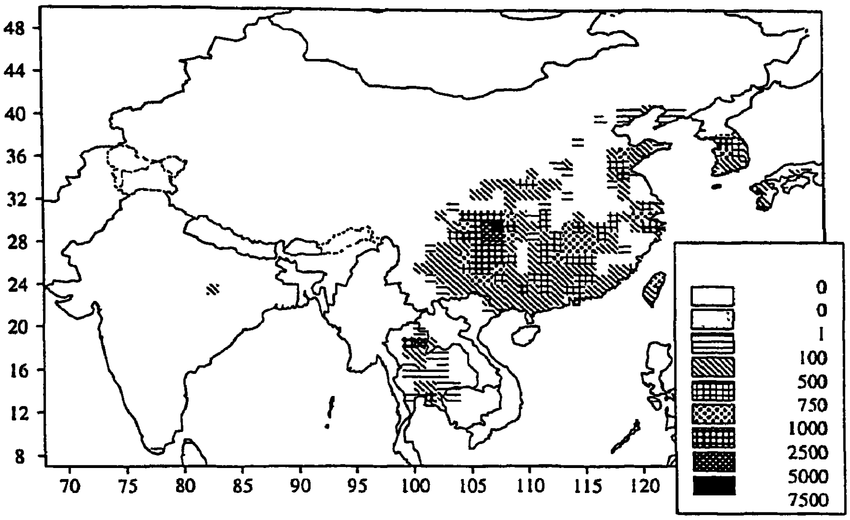

Figure 2.4: Excess S deposition above the sustainable levels of sulfur deposition (the critical loads, 25th percentile) in China and India in 1990, in acid equivalents/ha/year

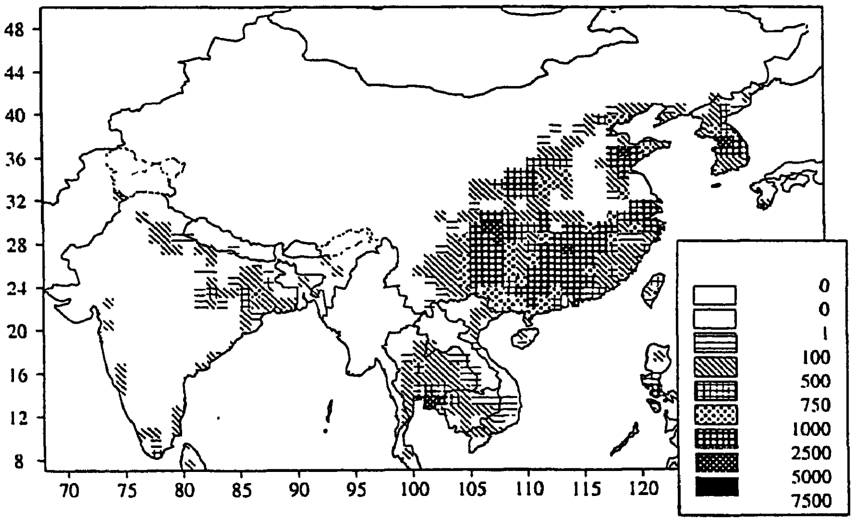

Figure 2.5: Excess S deposition (above the sustainable levels of sulfur deposition (the critical loads, 25th percentile) in China and India, "current legislation - business as usual" (BAU-CLE) scenario in the year 2020, in acid equivalents/ha/year.

2.3.3. Cost-optimized Scenarios for Controlling SO_2 Emissions

The optimization mode of integrated assessment models such as RAINS-Asia can be a powerful tool in the search for cost-effective solutions to combat air pollution. In the RAINS-Europe model, optimization techniques have been used to identify the cost-minimal allocation of resources in order to achieve environmental targets for acidification, eutrophication and tropospheric ozone. In particular, for acidification the target was to reduce the gap between present deposition of acidifying substances (sulfur dioxide, nitrogen oxides, and ammonia) and the ultimate European policy target of a full achievement of the critical loads. A description of the methodology used in the optimization module of RAINS-Europe can be found in Makowski *et al.*, 1999. Recently, a similar optimization feature was implemented in the Asian version of the model. Since, at the moment, RAINS-ASIA covers only sulfur pollution, the optimization is confined to the cost-effective abatement of sulfur dioxide emissions.

2.3.3.1. *Environmental Targets*

The cost-optimization is driven by environmental targets (constraints) on sulfur deposition. Deposition targets determine - for all grid cells in the selected model domain - the degree to which sulfur deposition needs to be reduced. The choice of a particular deposition target is up to the user; usually it reflects goals of environmental policies (e.g., to safeguard the protection of ecosystems against sulfur deposition) or to allow a certain excess of the sustainable deposition levels. Since the choice of appropriate policy targets for Asia is outside the scope of this study, four illustrative types of targets were prepared to demonstrate the impacts of alternative target setting schemes on the optimal strategy to control SO_2 emissions in the region. In no way these illustrative targets should imply any value judgement of the scientists developing the tool about appropriate policy targets for Asia.

- A first example set contains limits excess sulfur deposition, i.e., the maximum exceedance of critical loads, at the level of excess deposition experienced in a given year in the past.
- The second example maintains (for the year 2020) total sulfur deposition levels at the levels experienced in a given year, without relating them to environmental sensitivities/critical loads (the so-called "plain deposition" targets).
- The third target follows the "gap closure" concept, i.e., the optimization has to reduce excess sulfur deposition (above the critical loads) everywhere by the same percentage.
- The fourth target aims for equal exceedance of critical loads in each grid in a given country.

All optimization runs assume the "Current Legislation" situation as a starting point. This means that only measures that can be applied on top of current legislation are looked for, and a return to the uncontrolled situation is not allowed. Two alternative sets of optimizations were performed:

- The first set included only "conventional" emission control technologies, i.e., the use of low sulfur fuels and flue gas desulfurization.
- The second set included also an increased use of renewable energy as an option to control SO_2 emissions in China and India.

2.3.3.2. *Optimization Results*

To keep in the year 2020 excess sulfur deposition at the 1990 level, it would be necessary to reduce SO_2 emissions by 9.3 million tons in China and by 4 million tons in India on top what is expected from the CLE case. Costs of these additional reductions are more than a factor of three above the CLE costs: they increase from 2.7 to 8.3 billion US$/year in China and from 1.4 to 5.1 billion US$/year in India.

Obviously, less ambitious measures are necessary if excess deposition of a more recent year is taken as a target. For instance, if the 2000 excess deposition is used for target setting, costs increase by only 1.5 billion US$/year in China and by 2.5 billion US$/year in India.

It is important to realize that in India optimized scenarios using targets related to total sulfur deposition are much more expensive than those related to excess deposition, while the environmental impacts should be comparable. This is caused by the fact that critical loads in India are relatively high, and deposition levels in 1990 much lower than those observed in China. Therefore, a policy aiming at reducing harmful excess deposition needs to cut less sulfur emissions (since many of the emissions do not cause harm to ecosystems), while a policy aiming at bringing total sulfur deposition levels back to values observed in the past imply unnecessarily stringent measures that do not bring additional environmental benefits.

For illustration, a 30 percent "gap closure" target was selected that resulted in a similar level of costs and emission controls as the "excess deposition at 1995 level" (ED95) scenario. However, the distribution of emission reductions is rather different, if the "equal environmental improvement" rationale of the gap closure concept is adopted. An "equal exceedance" (EE) target (2 g $S/m^2/yr$ for

China and 0.5 g S/m2/yr for India) is much less demanding since it exclusively focuses on the worst polluted areas, while there is no incentive to take action in most parts of the countries, where excess deposition is less serious. Compared with the ED95 target, the emission control costs for China are lower by 0.3 billion US$/year (about 5 percent) For India the costs decrease by more than two billion US$/year, or by 54 percent, compared with the ED95 case.

The analysis clearly indicates that emission reductions required by cost-efficient solutions are not uniform among the regions. Figure 2.6 compares the reductions implied by selected scenarios for the regions in China. The percentages refer to the unabated emissions in each region in 2020. The last column at the right side of the graph demonstrates the average values for the whole China. The emission reduction requirements depend on the stringency of deposition target. Whereas the "Current Legislation" (CLE) scenario results in about 20 percent average emissions reduction, the "excess deposition at 1990 level" (ED90) scenario implies a reduction in the whole of China by 45 percent. However, for nine regions reductions above 50 percent are necessary. In turn, in four regions with less sensitive ecosystems reductions below 20 percent are sufficient.

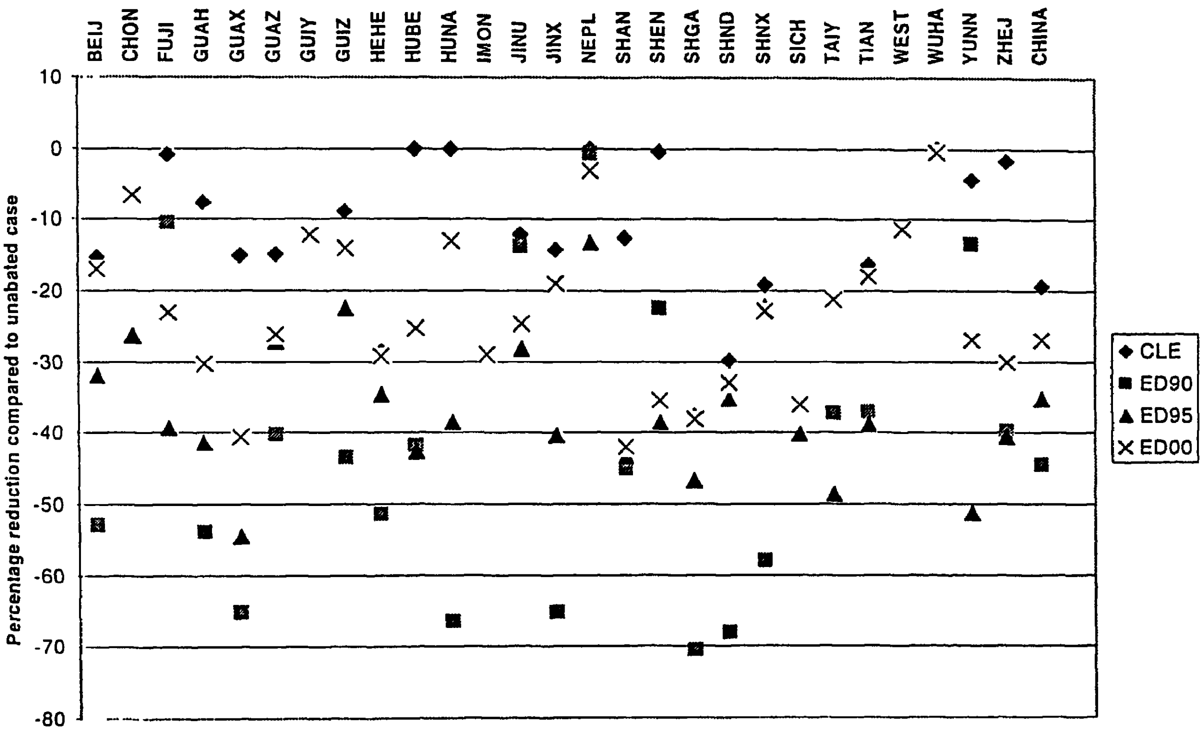

Figure 2.6: Regional sulfur emission reductions in China for individual scenarios compared with the unabated SO_2 level in 2020

If substitution of conventional fuel by renewable energy is considered as an option to control SO_2 emissions, emission control costs for the same environmental targets are much lower. For China, the decrease in costs caused by the full implementation of cost efficient renewable options ranges between 17 and 33 percent, depending on the deposition target. For India the costs are reduced by at least two thirds. Renewable energy could be grouped into three classes:

- There are forms of renewable energy that are cheaper than conventional energy even without considering their effect on SO_2 emissions (small and large hydropower plants and wind mills for electricity generation, use of biogas in certain industries, solar thermal, geothermal and dung in the domestic sector). In the business as usual case, a variety of institutional barriers prohibit the full use of the cost-saving potential.
- Other forms of renewable energy have a potential for reducing SO_2 emissions, but at positive costs and they have to compete with emissions controls for conventional energy. The exact identification of cost-effective measures is crucially depending on the environmental ambition level (i.e., the extent to which SO_2 emissions need to be reduced). For reasonably stringent targets, further use of wind power, solar thermal and biogas are potential candidates that could substitute more expensive emission controls for conventional energy.
- The costs of the third group of renewable energy are higher than the cost increments for SO_2 control of conventional energy. An increased use of this energy cannot be economically justified exclusively on the basis of SO_2 control; however, they contribute in addition to a reduction of CO_2 emissions, and separate analyses will be necessary to determine their cost-effectiveness for the reduction of greenhouse gases.

Figure 2.7 and Figure 2.8 illustrate the trade-offs between sulfur emissions and emission control costs in China and India. By relating the optimal national emission reductions with optimal costs for different deposition targets and different cost curves, these graphs suggest two important observations:

- The required amount of emission reductions depends first of all on the stringency of the environmental targets and only to a limited extent on the selected energy scenario (the form of the cost curve).
- Emission control costs can be much lower if structural changes in energy systems, in this particular case an increased utilization of renewable energy, are implemented.

Compared with the current legislation case (Figure 2.5), the area affected by deposition exceeding critical thresholds decreases in all optimized scenarios, and also the absolute values of exceedances are lower. There are, however, important trade-offs between environmental improvement brought about by each of the scenarios and emission control costs. Thus the choice of environmental targets needs to be done by authorities responsible for environmental policy making in each country.

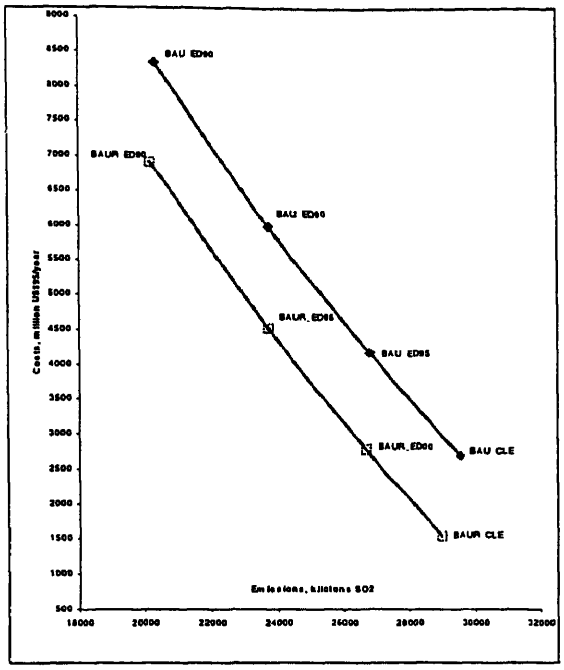

Figure 2.7: Results for China: cost-efficiency of SO_2 emission reductions by 2020 for the Business-as-Usual scenario including current legislation for SO_2 emission control (BAU-CLE and BAUR-CLE) and a number of optimization runs assuming different sets of deposition targets. The upper line presentes the results of the analyses taking into account only end-of-pipe technologies for SO_2 control (BAU runs). The lower line presents results taking also into account renewables as option for SO_2 control. Results from RAINS-ASIA (BAUR runs). The targets limit excess sulfur deposition in China and India over 25th percentile critical load (ensuring protection of 75% of the ecosystems) for each grid cell to the level calculated for 1990 (ED90), 1995 (ED95) and 2000 (ED00). (Amann et al., 2000; Boudri et al., 2000)

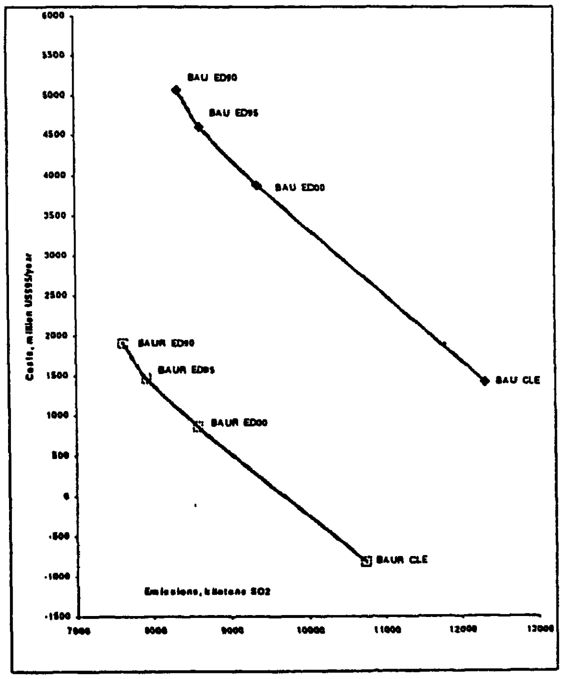

Figure 2.8: As Figure 3 but for India

3. Review of Present Policies to Promote Renewable Energy

3.1. *Renewable Energy in IEA Countries*

Most of the IEA countries are developing renewable energy in order to

- reduce local air pollution,
- reduce the emissions of greenhouse gases,
- diversify energy supplies, and
- create jobs and promote exports.

Renewable energy promotional policies have been strengthened in many IEA countries over the last years, with significant advances seen in the importance of renewable energies in some countries. Governments of individual IEA countries use a diverse range of policies to increase the use of renewable energies. Depending on the situation in a given country, the governments concentrate on the promotion of different renewable resources and use different policies.

Policy measures used to promote renewable energy are diverse. They include traditional policy instruments such as capital subsidies, tax exemptions, promotion of research and development (R&D), as well as some newer instruments such as voluntary actions, competitive bidding procedures for a specified market share, "green pricing" and renewable enter targets.

3.1.1. Market Stimulation Incentives

Major objective of market stimulation incentives is to create or enlarge the market for renewable energy technologies. The most important measures in this policy category include buy-back rates, capital or output credits, tax exemptions and special pricing mechanisms.

Buy-back rates

Most of the IEA countries emphasize the use of renewable energy for electricity generation (rather than heat production, direct use, or bio-fuels for transport). Thus the most critical area influencing development of renewable markets are the regulations governing the purchase of renewable electricity and the buy-back rates for this electricity. The level of payment for renewable electricity varies among the countries. Sometimes there are regional differences within a given country. For instance, Germany pays renewable electricity generators up to 90% of the price paid by the end users. In the UK, the Non-Fossil Fuel Obligation guarantees pre-determined electricity price for certain government-selected renewable electricity projects. In Japan, the buy-back rates for electricity from photovoltaics (PV) and wind are set at same level as consumer prices.

Capital subsidies

Capital credits for the purchase and installation of new renewable equipment are available in some IEA countries including Belgium, Finland, Japan, the Netherlands and Sweden. They enable to overcome the barriers associated with a high initial cost of renewable options. Provisions for capital subsidies for renewable systems are also in place in Italy, although the budget situation has caused that no subsidies have actually been disbursed. Many capital credits are set up as an, often capped, percentage subsidy. The observed range is from 10 to 67 percent of the capital cost of installation. In general, smaller systems that produce the most expensive energy, such as PV, benefit from a higher subsidy. The subsidy rate for such systems is about 50 to 67 percent.

Tax policies

Tax exemptions in the form of tax relieves, credits and deferrals are other commonly-used measures, and are in place in Australia, Belgium, Canada, France, Japan, the Netherlands and United States. The

US scheme allows for up to 10% of the investment costs in solar and geothermal projects to be set against taxable income. In same countries, like for instance in Denmark, energy tax is used to promote renewable power sources.

Credit support

Other incentives for renewable energy include credit support in the form of loans. Such loans are available in Australia, France, Japan and in the US. In those countries, incentives have been provided for feasibility studies of renewable energy projects. For example, the Netherlands reimburses 50 percent of the cost of the studies on wind potential. In Japan funds up to 10 million Japanese Yen are available for studies on decentralized power generation.

Green price

The green price is one of the newest policies developed for promoting renewable energy, and has had an encouraging start to date in the limited areas in which it has been introduced. Governments and utilities are generally favorable towards such schemes because it entails little or no cost for them. Most successful program has been developed in the Netherlands. Some time the green price action is combined with voluntary actions. In the Netherlands, people can buy green power with higher price than the normal power price.

3.1.2. Government Actions

Government actions are also incentives for the market penetration of renewable energy technologies in the IEA countries. Major actions of the governments concentrate on: setting up government targets; developing regulations, standards, and planning measures; initializing voluntary actions; launching information and education programs; and supporting research and development programs.

Government targets

Governments of all IEA countries have set targets for future renewable energy use. Renewable energy target may cover just one renewable energy source and be linked to a specific policy, as for example, the solar PV roof-top program in Germany, US and Japan. From the other side, the European Union has developed a strategic action plan, which sets a detailed target for each county and each type of renewable energy. Governmental targets indicate the market potential for both technology and business developers. RPS (renewable portfolio standard) is one of the government actions for targeting renewable energy development. [explain in the footnote what is the RPS]

Regulations

Regulations, standards, and certification are the measures to ensure the quality of renewable technologies and to increase the market acceptance for such kind of technologies. Incorporation of renewable-specific incentives/standards/guidelines in building codes and design/architectural guidelines is critical for the adoption of active and passive renewable designs in new and modified building stocks. That type of regulation has been used in Belgium and Germany. Lack of standards for technical performance and/or safety or planning requirements, may cause bureaucratic barrier to increased renewable energy development.

Voluntary actions

Voluntary actions can range from formalized and binding negotiated targets between the government and electricity utilities, to more informal approach aiming at encouraging renewable energy technologies.

Information and education

More than a half of the IEA countries have initiated information and education campaigns which aim at overcoming the barriers due to lack of information on renewable energy that hinders its increased development. Usually the renewable energy associations take the responsibility for dissemination of information, and for launching the education and training programs.

Research and development

Government-funded renewable energy R&D are employed in one form or another in all IEA countries and are generally complemented with support from industry. The total annual renewable energy R&D expenditure accounted about 0.8 to 1.0 billion US$, which is about eight percent of total budget. R&D has provided market opportunities for some of the renewable energy technologies for IEA countries, such as wind, solar PV and biomass.

3.1.3. Barriers to Renewable Energy Development in IEA Countries

There are still many barriers to renewable energy development in the IEA countries. The most important barriers are the high cost and policy changes.

High costs

Most of the renewable energy technologies are costly. Even the near commercialization stage technologies, such as wind, have much higher cost then the conventional energy. Table 1 compares the cost of power generation from renewable sources with the costs of conventional power. The results indicate that most of renewable energy needs various subsidies in order to be competitive with conventional sources.

Table 3.1: Cost of renewable electricity in selected IEA countries, US cents/kWh

	Japan	NZ	Sweden	UK	USA
Reference price (conventional power)	n.a	2.6 – 2.8	3.9 - 4.5	4	3.7 – 4.3
Large wind	43.6-45.7	4.5-6.3	4.2-5.6	6-8	5-6
Hydro power	n.a	4.4-5.7	3.5-4.9	6-7	n.a
Municipal waste? (MSW)	8.5-9.6	n.a.	n.a	5.9	8.5-10.6
Geothermal	13.8-17	3.6-5.7	n.a	n.a	9.2
Biomass	n.a	2.6	4.3-5.3	13.3	9-11
PV	138	n.a	n.a	n.a	19.6-42.4
Solar thermal	n.a	n.a	n.a	n.a	20-22

Policy changes

Government policy can promote renewable energy development. But it can also kill the renewable energy technologies. For example, during the 1980s, US had developed strong incentives for renewable energy development. As the results, US was the leader of renewable energy in the world, especially in solar PV, solar thermal and other. However, after 1990s, most of the incentive measures have disappeared, which resulted in the stop of renewable energy expansion both in technologies and market development, especially in solar thermal and wind. Currently, Germany, Spain, and Denmark are the world leaders in the renewable energy development. In Germany and Spain the annual growth in installed capacities of wind power is higher than 100 percent.

Subsidies to conventional energy

Another policy barrier to renewable energy development is the subsidy to the conventional energy. For instance, coal subsides in Germany are about 100 US$ per ton. Such subsidies limit the competitiveness of renewable energy.

3.1.4. Renewable Energy Policies in Selected IEA Countries

United States

US federal government's renewable energy production incentive and tax credit (REPI) are the major economic incentives for renewables right now. In addition, many states offer extra tax incentives to promote renewable energy manufacturing and deployment within the state. The 1992 Energy Policy Act (EPACT), established several policy incentives for renewables:

- A permanent 10% energy tax credit for solar energy and geothermal projects. However, this tax credit is not available to utilities;
- A ten-year, 1.5 US¢/kWh production tax credit (PTC) for wind and closed-loop (energy crop) biomass projects. This tax credit is indexed according to the general inflation rate, and till 1997 it has risen to about 1.65 US¢/kWh. To quality for the REPI, the renewable energy facilities have to be operational before July 1, 1999.

Besides the Federal government, some states have set up additional economic incentives for renewable energy development.

Denmark

As means of meeting the objectives of their national energy plan, Denmark offers relatively generous financial incentives for renewable energy, such as wind power generation. The following major economic and financial incentives are used:

Electricity tariffs in Denmark comprise of two components: (a) the utility costs of generating and delivering electricity (6.2 US¢/kWh), (b) carbon dioxide, electricity, and value added tax. In 1996 the total tariff was 9.3 US¢/kWh. The wind power purchase price was 5.2 US¢/kWh (85% of the utility power generation and transition cost plus 4.2 US cents/kWh production incentive);

The initial US$ 450/year of income from a wind power project and 40% percent of the remaining income is tax-free;

For private individuals, only one turbine is allowed to be connected to the grid.

Germany

Germany offers financial incentives for gird-connected wind, solar PV and other renewable energy systems. In particular:

- the price of wind based electricity can be as high as 90 percent of the end users' price;
- the price of other renewables can be set at 65 to 90 percent of the end users' tariff;
- Corporate and personal income tax deduction, is possible; this deduction is equal to 10% of wind energy investment per year for 10 years;
- Supply subsidized loans can be available from state development bank (DtA) and other banks. The loan can cover up to 100% of the project cost with 1 to 2 percentage point lower interest than from commercial banks.

The Netherlands

The Netherlands offers a mix of financial incentives for renewable energy. The major incentives include:

- national target for renewable energy. This target has been set at 10% total energy demand by 2020;
- fiscal support for renewable energy investment (30 % subsidy is possible);

- green funds;
- tax credits;
- fast depreciation;
- energy tax equal to 8.20 Dfl cents/kWh (electric);
- pay back to renewable electricity: 3.54 Dfl cents/kWh (electric);
- no tax on green electricity since 1-1-1999.

3.2. Renewable Energy in India

3.2.1. Introduction

The annual compounded growth rate of commercial energy consumption in India has been around 5.5% during 1992-97. However, the per capita energy consumption still remains less than 10% of the levels achieved in the industrialized market economies. Indeed, if the standards of living are to increase, it is inevitable that energy demand must rise. Similarly, to maintain a reasonable industrial growth, the country must have a sustainable energy supply. But the state of affairs in the field of energy reveals a disturbing picture. Traditional fuels, characterized by low efficiency levels (10-15%) still account for as much as 41% of the country's energy supplies. Persistent energy shortages loom dangerously as demand continues to outstrip supply. The situation becomes more alarming due to the fact that the continued burning of fossil fuels endangers the climate through such phenomena as the global warming. Fortunately, India has an abundance of renewable energy sources e.g. the sun, wind, biomass and hydropower. By carefully matching different forms of renewable energy to different end-uses, such strategies can reduce per capita energy demand (of conventional sources) and still allow for continued economic growth. Besides, renewable energy sources not only provide energy, but also contribute to afforestation, drought control, improvement in the environment, energy conservation, employment generation, upgrading of health and hygiene, social welfare, security of drinking water and agriculture, and production of bio-fertilizers. Thus, it is evident that in order to have a sustainable development approach, the energy-mix has to have substantial share of renewable energy resources.

Renewable energy sources are indigenous, and can therefore contribute towards reduction in dependency on energy imports, thereby strengthening energy security. Renewable energy sources assume special significance in India when viewed in the context of the diversity and size of the country. Since renewable energy resources are diffuse and decentralized, they are more appropriate as local energy systems, meeting ever expanding and diversified energy needs. In this perspective, they offer numerous possibilities for meeting the basic energy needs of the rural poor. This apart, renewable energy offers significant possibilities for job creation. Such jobs would also help to arrest rural to urban migration.

To summarize, the increased use of renewable energy resources is necessitated by the

- inability of the conventional systems to meet growing energy demands in an equitable and sustainable manner,
- need to efficiently and economically meet the energy needs of all the country's citizens, particularly the rural poor,
- large-scale impact of conventional energy production and consumption on the physical and human environment.

The consistent and continued national initiatives for the promotion of renewable-energy technologies have placed India at the forefront of the international effort to harness renewable energy. This ongoing momentum of renewable-energy development, coupled with the geographic benefits of renewable-energy resource abundance, provides a strategic benefit in exploiting renewable energy to complement conventional energy sources in meeting the basic energy needs of the rural population, as well as the rapidly increasing energy demands associated with high economic growth. These increases in energy needs are currently met by petroleum products or by fuel wood and other inferior biomass fuels. Renewable energy can increasingly satisfy these energy needs in an environmentally acceptable and cost effective manner while reducing dependence on imported fossil fuels.

3.2.2. The Experience with Renewable Energy in India

Though renewable energy technologies (RETs) such as biogas plants and improved cook stoves have been available in India since the late 1940s, the renewable energy programme was initiated in India on a very moderate scale in the wake of the energy crisis of 1973 when abundant endowments of renewable energy sources – solar, wind, small hydro, biomass, ocean thermal – received closer attention. As a follow-up to the 1981 UN Conference on New and Renewable Sources of Energy, which underscored the need for drawing up plans for achieving a harmonious transition from an economy based on hydrocarbons to one based on renewable energy resources, the Government of India decided to set up a high-powered Commission for Additional Sources of Energy (CASE). A separate Department was also created in 1982, under the Ministry of Energy, at par with Departments of Coal and Power, to provide focussed attention to this sector. After a decade, in 1992, the Government decided to give a further boost to increase the deployment of near or already commercial renewable energy technologies by upgrading the erstwhile Department to a full-fledged Ministry, named the Ministry of Non-conventional Energy Sources (MNES).

3.2.2.1. New Strategy and Action Plan

Till mid 1993, the MNES was organized broadly based on technology. The individual technologies were promoted through design and development support, and through the establishment of large-scale demonstration programs, e.g., the national programs for biogas development, cookstoves dissemination, and wind energy. Through these programs, a RET manufacturing base was created. The RET devices were procured by the government, either for demonstration projects (as for wind energy and for SPV community-lighting and power plant programs), or for subsidized sales to consumers. A number of technology-support centers were created to promote technological upgrade by manufacturers, and to certify the quality of devices procured by the government. The programs were led by Government subsidies, and implemented through state nodal agencies. However, investment in the promotion of renewable energy was low in comparison to those for conventional energy sources. The cumulative government expenditure for the renewable energy sector between 1980 and 1992 totaled to only Rs 11.55 billion, which was about 0.8 percent of the total funds allocated for the energy sector.

In order to give the required focus on commercialization, market orientation, and in order to have greater involvement of the private sector, the MNES was restructured in 1993 on the basis of end-use applications of technologies through horizontal integration of various technologies. The restructured MNES now has sectoral groups for (i) rural energy, (ii) urban/industrial energy and (iii) power generation.

Under the New Strategy and Action Plan of 1993, the following, two-pronged Action Plan was devised:

- High priority accorded to generation of grid quality power from wind energy, small hydropower, bio-energy and solar energy.
- Rural energization programme promoted through:
- electrification of villages through photovoltaic and biomass gasifier power systems
- supply of solar lanterns to unelectrified households
- use of solar water heating systems
- rural energy programs viz. National Project on Biogas Programme
- production of energy from agricultural waste, etc.

A three-fold strategy has been pursued by the government for promotion of renewable sources of energy through private sector involvement, including:

- providing budgetary resources by government for demonstration projects.
- extending institutional finance from the Indian Renewable Energy Development Agency (IREDA) and other financial institutions for commercially viable projects, with private sector participation; and external assistance from international and bilateral agencies.
- promoting private investment through fiscal incentives, tax holidays, depreciation allowance, facilities for wheeling and banking of power for the grid and the remunerative returns for the power provided to the grid.

Through the restructuring, emphasis shifted towards policies, planning and institutional linkages to promote RETs within each sector. Each such sector now consists of integrated programs to serve different energy needs; for instance, cooking energy is now dealt with comprehensively under the Rural Energy Group rather than individual technologies being implemented separately.

The restructuring has also lead to shift from direct financial incentives (e.g. subsidies) to indirect fiscal incentives (e.g., low interest loans, financing packages for consumers, reduced tariff and taxes, viable power-purchase prices, etc.). This has stimulated private-sector investment in wind and SPV power plants, as well as encouraged RET manufacturers and financing intermediaries to address the needs of consumers in their product design. The resulting growth of the RET market has been impressive. Table 3.2 shows RET penetrations till 1993 (before restructuring), and till 1999. Significant increases have occurred in wind-energy generation, SPV domestic lighting (particularly solar lanterns, which were earlier not even a part of the national programs) and water pumping, and family-sized biogas plants as a result of the market-based commercialization of RET deployment.

Table 3.2 : Estimated potential and installed capacity of major renewable energy technologies in India

Technology	Potential	Cumulative installation up to	
		March 1993	December 1999
Family-size biogas plants	12 million	1.76 million	2.9 million
Improved cookstoves	120 million	14.5 million	31.1 million
Solar	20 MW/km^2		
Solar thermal			
Solar hot water systems (m^2)		0.25 million	0.48 million
Solar cookers		0.29 million	0.48 million
Solar photovoltaics			47 MW
Water pumps		756	3157
Power units		410 kW$_p$	1920 kW$_p$
Community lights and street lights		29 972	40 000
Home systems		14 594	100 000
Lanterns		—	250 000
Biomass	17000 MW		
Biomass gasifier		—	34 MW
Bagasse co-generation	3500 MW	—	222 MW
Windfarms	20000 MW	53 MW	1080 MW
Mini/micro hydro-electric	10000 MW	93 MW	217 MW
Waste to energy	1700 MW	—	15.21 MW

These policy regimes have been successful in the creation of a fairly large and diversified manufacturing base, and in the creation of an institutional framework and delivery mechanisms etc. to support research, development, demonstration, deployment and extension. Since 1993, there has been appreciable private-sector investment in wind electricity, bagasse co-generation and some solar photovoltaic applications, and manufacturers and financing intermediaries have initiated innovations to address the needs of consumers in their product design. It is noteworthy that renewable energy contributed to 1050 MW against 16,900 MW of conventional electric-generation capacity added in the country during the Eighth Plan period (1992-1997). This growth is based on a few crucial policy and institutional interventions: assessment of renewable resources and the dissemination of this information; public support for "early-bird" projects; availability of credit through IREDA; and the development of guidelines for quality assurance and grid purchase of electricity from renewable energy.

A growing and competitive domestic market for renewable-energy products would also allow the renewable-energy industry to exploit the international market inasmuch as an increasing share of global energy needs are expected to be met by renewable energy in the years ahead.

3.2.3. Barriers for the Propagation of Renewable Energy in India

The current policy environment has been successful in creating one of the largest and most diverse renewable energy programs in the world, with a broad technological base and large human capacity. With these strengths, the renewable energy technologies are now poised to move into the energy mainstream. However, despite these accomplishments, there are still the following major lacunas:

- The markets and market-support infrastructure for renewable-energy products are still underdeveloped.
- Product development is poor, and continues to be largely supply driven rather than being responsive to user needs.
- The linkage between the market requirements (for product development, deployment and technology upgrade) and the research & development process is weak.
- There is limited access to renewable energy based products and credit.
- Provision of high-quality energy services from renewable energy (through hybrids or dedicated energy-service companies is completely lacking.
- The incorporation of renewable electricity into the state grids is constrained by the lack of consistent policies, and current tariffs discourage both standalone and local grid-based renewable energy systems .

3.2.4. Critical Issues

The key issues facing renewable energy technologies depend on their level of technological maturity and the kind of market that they face. The different RETs in India, thus could be broadly re-grouped, based on their level of technological maturity and markets, in the following manner:

- Technically mature RET systems
    - Grid connected electricity generating technologies

      (Wind, solar PV & co-generation)
    - Stand alone electricity generating technologies

      (Wind, solar PV, biomass based co-generation systems)
    - Stand alone thermal systems

      (Solar water heating systems, solar cookers, co-generation, biogas)

- New and Emerging RET systems
  - Grid connected electricity generating technologies
    (Solar thermal, geo-thermal, tidal, ocean thermal energy conversion)
  - Stand alone (or decentralized grid-interactive) electricity generating technologies
    (Hybrid systems, fuel cells, biomass gasifier-based co-generation)
  - Stand alone thermal systems
    (Solar pond, geo-thermal)

For the purpose of classification, mature technologies are those that offer acceptable levels of reliability and energy-efficiency to users; though they may not be commercially viable. The key issues within each of these technology subsets are dealt with in detail in the following section.

3.2.4.1. Technically Mature RET Systems

These technologies have been prominent for more than a decade. Evolving policy frameworks and programs have led to development of support infrastructures like manufacturing base, servicing and maintenance networks, financing options, fiscal incentives, mature institutional settings and relationships, etc. Development of such mechanisms and regulatory frameworks led to the establishment of over 1100 MW of grid connected Wind Electric Generators (over 95 percent of which is due to private sector participation), making India the fifth largest producer of wind electricity.

Some of the issues which are common to all technically-mature RETs (for grid connected or stand alone electricity, and for thermal applications) are discussed below:

Pricing of conventional energy

The present electric supply structures is dominated by nationalized utilities, producing electricity from conventional thermal route based on coal or gas. Conventional power producing options employ fossil fuels, which in turn lead to local air pollution and GHG emissions at a global level. Moreover, these resources are finite in nature, and exploitation of these resources has adverse effects on the ecology through mining, deforestation, pollution emissions, transportation, displacement etc. At present, there is no economic disincentive for conventional power producing options, which have adverse environmental impacts. A full cost estimate of coal generated electricity triples the financial cost, rendering it more expensive than wind or biomass co-generation.

Moreover, the utility power is highly subsidized due to which stand-alone RET projects become economically non-viable. It has been estimated that when prices reflect costs, decentralized RETs are the least-cost option for about 50% of rural communities (which are characterized by low loads and long distances from the high-voltage grid).

Mechanisms such as economically efficient tariff setting and environmental disincentives for conventional power producing options are required in order to provide a level playing field for RETs. Alternatively sufficient incentives should be given to make RET a viable option. The regulatory commissions, envisaged under the Electricity Regulation Bill, should be charged with the mandate to incorporate environmental costs in the generation tariff, apart from ensuring transparency of costs in the pricing structure.

High initial and transaction costs of RETs

Current energy generation cost from RET option is high, due to (1) high capital cost (Rs. 5-20 crore per MW) and low capacity factor (15-24%) in comparison to conventional power producing options (Rs. 4 crore per MW and a plant load factor of 50-70%). It is evident that capital cost and capacity factor are major drivers of generated electricity cost. Further, in spite of increased installation of RET systems, cost reduction is not occurring in a proportionate manner.

Since the RET market is still evolving, the market chains (of suppliers, dealers, credit facilitators, maintenance and spares supply organizations) have yet to be established. Due to this, each of these market actors has to spend a lot of time and effort to find, and more importantly, evaluate the "business-worthiness" of the other market actors. Consequently, there is a strong need to create the market-support infrastructure for the RETs so as to bring down the transaction costs of RET implementation for these market actors.

3.2.4.2. Grid Connected Electricity Generating Technologies

Most popular grid connected RET systems are wind electric generators, solar photovoltaic systems, and bagasse co-generation units. Present technologies employed in these systems have proven their technical value and reliability to a great extent. Chiefly, the end use application of these technologies is to supply electricity to the utility grid, or for banking and captive power production. Hence, for all practical reasons they have to compete with the conventional power producing options employing coal or gas or diesel. Further, to ensure a stable growth of this sector, product upgrade and development is very important. In order to achieve full commercialization, following issues needs to be highlighted and resolved at the policy, institutional and implementation level.

Sales and maintenance infrastructure

Performance of grid connected RET *systems* has been very poor (for example, capacity factor of 18% for wind energy, against a projected 21-24 percent). Most of the sites where these systems are deployed are either far-off or cut-off from the main transport networks, due to which the manufacturers are not able to cater to the O&M needs of the developer. This has led to one private O&M services, but need is still felt for more O&M providers. In this respect, proper maintenance infrastructure and guidelines needs to be created for ensuring the reliability and higher capacity factor of grid connected RETs.

Power evacuation network

Power evacuation set-up is extremely important for ensuring higher capacity factor and revenue generation from the project. State Nodal Agencies; have not been proactive in this direction. Sometimes power evacuation network cannot cater to the installed capacity of the site (which is much more), leading to downtime of grids, during high wind speed seasons.

Adequate power evacuation setup and its appropriate upgrade have to be ascertained and planned in a proactive manner. Renewable resource assessment and RET-electricity generation must be incorporated in the planning process of the electricity boards. Again, state electricity regulatory boards could provide the oversight function for this process.

Incentives linked to up front cost of RETs

One of the reasons for the high cost of RET devices in India (while it is decreasing in the international market), is the linkage of the fiscal incentive with the capital cost itself. This has made the market somewhat ignorant about the cost per unit generated in RET systems, and encouraged gold plating of capital costs.

Consequently, the policy on investment based fiscal incentive, needs to be changed to energy production based incentives. This might have direct bearing on the cost reduction and higher c.f. realization in RET systems.

Lack of indigenous R,D&D and product development

Most of the grid connected RET systems available and employed in India are either imported or are a result of a joint venture of an Indian company with a counterpart from Europe and America. Moreover, most of these systems are not designed as per the Indian site and grid conditions, some of which are listed below:

- Most of the wind turbines installed in India are not optimized for Indian site and grid conditions. Indian wind regime is of low density in opposition to higher density in Europe. Consequently, the amount of structural materials required is much less for Indian site applications. Moreover, amount of fluctuations registered in Indian grids is far greater than in the stable grids of Europe. This leads to frequent emergency breaking and tripping of systems. Rigorous R, D&D efforts to adapt technology to the Indian condition is required, which in turn can lead to cost reductions.
- For achieving higher capacity factor, grid interactive turbine design is a necessity. Most of the turbines employed in India are fixed speed (pitch/stall regulated), in opposition to advanced machines employing superior grid interactive mechanisms and variable speed drives which are able to register a capacity factor of as high as (23 to 25percent).
- Indigenous R, D&D can help in adopting the designs as per the Indian conditions, and help in developing superior technology (like variable speed drive).

Multiple institutions and their relationships

Propagation of Grid connected RET require appropriate PPAs, and transparency in institutional relationship. Presence of many institutions creates complexity and cracks between their role and responsibilities. Proper role definition, single window systems, proper evaluation of RET based IPPs should be worked out, and implemented, such that it fill the cracks existing as of today. Guidelines for wind energy issued by MNES have worked well in bringing together various actors, and reducing their perceived risk. Similar guidelines and default-templates for financing transaction would be useful.

3.2.4.3. Decentralized RETs: Stand-alone Electricity Generating Technologies and Thermal Applications

In opposition to grid connected RETs, the end application of which is chiefly to sell electricity to the utility grid, stand-alone RETs are based on user needs, and their end application may vary from lighting in night schools to PV refrigeration units in Primary/Rural Health Centers. These systems are gaining acceptance in rural areas due to lack (or non-reliability) of utility grids. But it can be anticipated that these systems will become popular in urban areas due to the expected differential tariff structure and frequently occurring power shortages.

From an end use point of view, areas of decentralized solar thermal energy utilization are traditionally classified as: solar water heating, solar cooking, solar air heating (drying), solar cooling, solar passive architecture, solar ponds, desalination, solar (thermal) water pumping, solar (thermal) power generation, biogas and co-generation. In the Indian context, solar industrial process heat applications dominate the scene.

Most of these technologies like solar water heating systems, solar cookers, etc. have urban, semi-urban and rural markets, while biogas has a traditional semi-urban and rural market. The major issues associated with this sector largely relate to the establishment of viable and sustainable markets.

Financing options, sales, service, maintenance and market support infrastructure

The main market of these systems is in rural and semi-urban areas. Unfortunately, these areas are not fully equipped with the required level of sales, services, maintenance and financing infrastructure. Lack of such infrastructure and after sales services, becomes an obstacle for market penetration. Moreover, most of the credit facilities can be availed only in cities; there is an absence of pervasive micro-credit networks at present, making it difficult for the consumer to avail the credit which is available for these RETs.

Secondly, in the case of newly mature technologies like solar pond, no specific financing option exists as on today. Financial institutions are hesitant because the perceived technological risk. Financial institutions like IREDA should take a lead role in financing such technologies, both for consumers, as well as for local dealers who need credit support for working capital and for marketing.

Network of rural co-operative banks and micro-credit societies should be facilitated and supported, as was the case in biogas, such that the customer can avail the credit facilities with ease. Novel financing methods like door-step financing, third party financing, financial intermediaries, etc. should also be tried out when and where required. The concept of ESCO (Energy Services Company), which has been tried out successfully in rural areas in Greece, also needs to be promoted through provision of credit for operating capital. ESCOs provide investment capital, install and maintain the equipment, and supply the user with energy services. In return, they get a guaranteed income stream from the consumer. This removes the investment risk from the consumer, and the sales risk from the ESCO.

Lack of R,D&D, product acceptability, development and upgrade

As these systems are user's need based, acceptability of the RET system by the beneficiaries is a prime issue. Options like development of efficient pumps for PV, the option of grid connected biomass gasifier DG set, and 100% fossil fuel substitution for biomass-gasifier based power generation are some of the issues which need to tackled at the R, D&D level.

Moreover the society and its needs are dynamic. A socio-technical approach coupled with indigenisation (R, D&D) of the product can help in saving the foreign exchange and aid in employment generation. Hence, allocation of appropriate funds and technology intervention to increase the efficiency and reliability of the system is very important.

Institutional relationships & training and entrepreneurship development

Presently the stakeholders involved in stand-alone systems and RET thermal systems are trading/manufacturing companies, financial institutions, State Nodal Agencies, and institutions involved in programs like IREP (integrated rural energy programme). After the 73rd constitutional amendment, the subject of 'non-conventional energy sources' was inducted in Eleventh Schedule. Further, the District Planning Committees, a legal constitutional entity under the 74th constitutional amendment, will play a major role for planning activities at the district level, in the coming years. Consequently, empowerment of local officials is essential.

As mentioned before, proper servicing and maintenance infrastructure is necessary for the growth of the sector. Various training activities and entrepreneurship development programme at the primary level should be encouraged and linked with employment generation schemes. Finally, proper networking and role definition of DPC's, State Nodal Agencies, MNES, REC's, SEB's, should be done for the future, such that it plays a progressive role in propagating RET systems.

Identification of niche markets

RET thermal systems do not produce electricity but convert one form of energy into other, e.g., solar energy into heat, biomass into heat etc. in opposition to RET thermal systems, stand alone systems generate electricity which might used for specific end use like rural refrigeration units, pumping activities, night lighting etc.

As both the sets of technologies are based on end use applications, appropriate niche markets have to be identified and targeted. Several industrial processes like dairy industry, cement industry and several other process industries require enormous amount of heat and mechanical power, while rural health centers and educational programs require PV based refrigeration and PV home systems respectively. It would be appropriate to "piggyback" RETs to the activities of conventional equipment suppliers in these markets due to their familiarity with their needs and requirements.

3.2.4.4. New and Emerging RET Technologies

Emerging technologies do not necessarily mean new technologies. These technologies, such as fuel cells, battery-powered vehicles, geothermal energy, ocean thermal energy conversion, magneto hydro dynamics etc., are currently not able to meet the market's expectation in terms of technical efficiency and reliability. Consequently, the key issues facing emerging technologies focus around ways and means to enhance their technological acceptability to end users. This acceptability would be the first step towards market creation and subsequent commercialization.

Emerging technologies themselves be over a relatively large spectrum of technological maturity. On the one hand, technologies such as solar thermal power generation and solar ponds have been field-tested and the technological community believes that they can be commercially utilized. The major emphasis in their development lies around convincing key users to participate in further demonstration and adaptation projects. On the other hand, technologies such as fuel cells and OTEC (Ocean thermal energy conversion) are still under technological development with the technological community still investing effort in system optimization and efficiency enhancement.

The key issues, therefore, span the range from technological development and proving, all the way to user participation in system optimisation and demonstration. The prominent issues are as follows:

Lack of comprehensive policy framework

Technologies employed in systems like solar pond, solar thermal power plant (sterling engine based) and hybrid systems are technologically viable. Due to lack of commercialization policy, no market creation activities in these field have been carried out till now. Moreover, support mechanisms like financing options, development of manufacturers etc., are almost non-existent.

These systems require proper policy intervention on the lines of market development linkages. Some specific issues, on these lines are discussed below for grid connected, stand alone and RET thermal technologies:

- **Grid connected electricity generating RET systems:** Realization and potential estimation coupled with suitable demonstration units is required, in technologies like solar thermal power plant, hybrid systems (PV-Wind, Solar thermal-gas, etc.) Further, this effort should lead to creation of appropriate infrastructure like institutional linkages, financing options, power evacuation facilities, model PPAs' etc., in order to commercialize them in the long run.
- **Stand alone electricity generating RET systems:** Stand-alone RET systems (both for electrical and thermal applications) should be based on user's need. Marketing studies as to the need and the level of acceptance and creation of required infrastructure could lead to design of appropriate systems and commercialization. Realization of niche markets and tailoring fiscal incentives to those consumers (as in the case of solar pond where the heat produced can be used by process industries), and programs like space heating in hilly regions through solar passive architecture, geothermal sources etc. should be taken into account.

These interventions occur at a decentralized level, but need to be thought out and planned at a central level. Consequently, support for technology for a where learning can be shared, and used to plan future interventions, should be helpful.

Technology intervention

As mentioned before, in order to commercialize emerging technologies, proper and specific technology intervention is required in technologies like fuel cell and OTEC. R, D&D partnerships with other countries that are further up on the learning curve prove helpful. Such partnerships should, however, fall within the scope of a larger national mission to prove these technologies. Prioritized mission-mode interventions would help in assembling consortia, as well as in periodically reviewing R&D goals.

Awareness generation among the niche markets and transportation energy

As mentioned before, process industries require enormous amount of heat, which at present is obtained by burning conventional fossil fuels; this can be substituted by technologies like solar pond.

Modern world consumes lot of energy in transportation, coupled with vehicular pollution in urban areas. Various countries have tried out options like battery powered vehicles, fuel cells powered vehicles leading to lowering of vehicular pollution. The present technology of fuel cell and battery options is not economically viable in opposition to conventional internal combustion engines. Realization of the potential, and creating infrastructure like battery charging centers, technology development in the area of fuel cells can lead to a reality of vehicular pollution free cities. Partnership with national/local environmental bodies and with which manufacturer is essential to ensure that the demand and the supply side of this market are created simultaneously.

Financing option

Due to lack of comprehensive policy framework and requisite infrastructure, there are no appropriate financing options available for private sector participation in new and emerging technologies. Government, through it's policies, should give importance to financing option to new and emerging technologies in terms of fiscal incentives, requisite subsidies etc., to manufacturer of new technologies. This would reduce their risk since financial returns on new technologies typically involve long lead times.

3.2.5. A Suggested Approach for India

In spite of such intensive efforts for putting up renewable energy technologies in the mainstream, commercial demand remains low, and dissemination is constrained by subsidies. This is largely because of a combination of factors such as level of product maturity and user-friendly features, low volumes, high initial costs, and the distortions in pricing in the energy sector. There is a need and room for accelerating market penetration and development. Improved product development and making available consumer acceptable product packages in the market place needs greater support. Consequently, product quality, effective delivery mechanisms (including credit and after-sales service), and the provision of high-quality energy services from renewable energy (through hybrids or local energy-service companies) needs to be promoted. The incorporation of renewable electricity into the state grids is constrained by the lack of consistent policies, and current tariffs discourage both standalone and local grid-based renewable energy systems. The linkage between the market requirements, for product development, deployment and technological upgrade, and the research & development process requires strengthening.

The cost-effectiveness of a system is a relative value because essentially it is determined on the basis of some base case. In case of RETs, this base case happens to be a conventional energy supply system. Secondly, economics of a particular RET also depends on its technological maturity. Thus, while solar water heating system-replacing oil could be economical in short term, solar thermal power would be cost-effective only in long term. Moreover, economic viability is dependent on the nature of application too. Solar PV technology which otherwise is a costly technology, could be very cost effective in niche application like powering a telecom repeater in a remote location. Therefore, the commercial value of a RET has to be examined in such a way that crucial aspects like reliability, capability to meet user's needs, replicability, and the environmental benefits accrued because of it are also taken in to account.

In the following section, broad categories of interventions are discussed:

3.2.5.1. Technology Development Related Interventions

Product and applications development based on users' needs.

The general approach so far has been oriented towards technology development. While this is essential in the initial stages, ultimately one has to look at the ways a particular technology would be put to use. Thus, as far as markets are concerned, it is not the technology *per se* but a specific product or application that is required and needed. Essentially this means that the approach to technology development should be demand driven rather than supply driven.

In case of RETs, in India, there has always been top-down rather than bottom-up approach. Thus, the systems available to the users are not what they need but what has been developed. Therefore, an appropriate model for public-private partnership for the development of renewable energy based products needs to be developed.

Mainstreaming of renewable energy products

The commercialization of renewable energy products is the ultimate aim of technology development. Therefore RETs, like all other technologies, must move from an initial stage (R&D) to a final stage (commercialization) within a reasonable timeframe, in terms of reliability, costs and acceptability.

Since the RET market is still evolving, the market chains (of suppliers, dealers, credit facilitators, maintenance and spares supply organizations) have yet to be established. Consequently, there is a strong need to create the market-support infrastructure for the RETs so as to bring down the transaction costs of RET implementation.

In this context, the aspect of energy service also needs due consideration. Given the high up front costs of renewable energy systems, the concept of vendors supplying the required energy to the consumers may be tried out. This way the consumer would not be burdened with the capital cost of the equipment. On the other hand, the energy supplier would also take care of operation and maintenance, etc.

Technology upgrade for mature technologies

For RETs that are near commercialization, a continuous process for the product/ technology upgradation is essential. Upgradation is required for a variety of reasons such as the performance enhancement, cost reduction, reliability enhancement, and making the product user-friendlier. Solar water heating systems, biogas plants, solar cookers, and improved *chulha* can be cited as examples where upgrade is overdue. Some public funds could be provided as incentives to leverage the effort and resources of the enterprises to enhance the performance of these products.

3.2.5.2. Interventions Concerning Economics and Finance

Financing through banks and financial institutions

Apart from arranging finances through the government supported mechanisms, another avenue could be developed for supporting RETs that is based on commercial banks, NBFCs (non-banking financial companies), and other financial institutions. So far as banks are concerned, renewable energy should be included in the priority sector lending norms. Similarly, it should be made mandatory for public sector financial sectors to earmark a certain portion of their overall budgets for RET financing, possibly at softer terms.

Yet, another way of financing relevant RETs (like solar water heating etc.) could be through *piggybacking* on other financial services like housing loans. This way repayment too would be assured.

Leveraging sectoral energy budgets

Ways and means need to be explored so that the existing budgetary support to MNES could be leveraged to its maximum potential, thereby garnering a much larger resource base. In order to increase the fund-size for renewable energy beyond the normal budgetary support, it is essential that energy components of the budgets of other ministries/departments should also be utilized for the purpose of RET propagation. One way of achieving this could be to make it mandatory, for example, that the annual reports of every ministry/department must show expenditure incurred on propagation of renewable energy, in addition to the energy conservation. Furthermore, there is a need to ensure that even the existing funds are utilized effectively and efficiently.

Other financial mechanisms, including CDM

To supplement the budgetary outlay of the MNES, there is an urgent requirement of tapping other sources of finances, such as those available under international financial mechanisms. For example the World Bank and the IFC, with GEF grant support, have provided Lines of Credit to national development banks where the interest rates have been reduced. These mechanisms have allowed renewable energy investors to sell electricity to utility grids at existing rates, and still enjoy attractive rates of return.

Bilateral and multilateral financing, provided through national grants, could also be used for capacity building. A number of renewable energy technologies are at the threshold of technological maturity. Many of these technologies (solar ponds, biomass gasifiers, industrial solar heaters etc.) have been demonstrated as prototypes, but useful products are yet to evolve. This product development (and upgrade) requires financing and technological support. Financing for this by bilaterals and by Foundations is possible when the product can be utilized to meet the programmatic objectives of these organizations – which could be poverty alleviation, rural development, and environmental pollution reduction etc.

International financing could also be used to supplement the national government funds for research and development activity, through interaction in R&D with the industrialized countries.

Clean Development Mechanism (CDM), which by way of attaching an economic cost to CO_2 reductions, improves the viability of renewable energy technologies multi-fold. Considering the high initial cost of renewable energy, CDM gives the projects an extra leverage.

The CDM could also be used as one of the means to finance performance-linked incentives for renewable energy. In this case, the additional incentive would reflect the avoided greenhouse gas emissions due to renewable electricity generation. In this way CDM, may prove to be beneficial from the perspective of increasing the share of renewable energy technologies in the overall energy-mix.

3.2.5.3. Interventions Concerning Institutional Aspects, Subsidy and Incentives

Infrastructural facilitation and project clearance

For such renewable energy projects that require land acquisition and other institutional/environmental clearances, there should be provisions that ensure that these are done automatically and expeditiously. Secondly, so far as infrastructural requirements are concerned, RETs should be accorded a priority over there.

Market development

Rural market for renewable energy products needs special support. Since the rural markets are under-developed, in terms of requirements and capacity (to absorb technology as well as of paying capacity), special emphasis needs to be paid to RET propagation in rural regions. Therefore, special schemes may have to be initiated that help in developing these markets.

It is important to note that since all renewable energy technologies are relatively new, there is currently poor technical capability to manage and service these systems, especially when they are installed in far-flung and widely dispersed areas. Consequently, the creation of market support infrastructure is a definite need.

Furthermore, laws and bylaws - such as building bylaws - should be modified suitably so as to encourage adoption of renewable energy technologies. Likewise, urban local bodies and industries should be required to set up energy recovery systems from wastes.

Provision of credit for working capital and marketing activities etc.

In the field of renewable energy, currently most of the manufacturers and suppliers are small time players with very limited resources. It is not possible for them to either carry out proper product improvement or to establish proper marketing network, including effective advertising. These manufacturers/suppliers could be provided with adequate working capital, on easy terms.

Credit availability for rural markets

For a number of RETs, The real economic challenge in widespread dissemination in rural sector is not the price of the system. Rather, the challenge is to device a suitable financing mechanism, which can spread the cost over a long period thereby matching the installment amount with the customers' ability to pay. India, being such a large country, has very divergent needs, user-profiles and paying capacities. Thus, it is imperative to tailor the product or service according to specific location and user-groups. Considering the fact that the up front cost of RE systems is very high, it is essential to include proper financing mechanism within the marketing chain. The pressure on the users could be eased out substantially through collaborative arrangements with the local, micro-lending agencies.

Awareness creation and dissemination

Adequate resources should be allocated for dissemination of research outcome and creation of awareness among the potential users and the public at large.

Promotion of enterpreneurship

Almost all the manufacturers of renewable energy systems mainly cater to institutional or large buyers. Consequently, there is practically no one to meet the requirements of an individual consumer, a kind of retail outlet. Consequently, local entrepreneurs could be trained, supported and nurtured to take care of the aforementioned needs of the consumers. They would also provide after-sales service and consumer financing.

3.2.5.4. Incentives/Subsidies

Investment based incentives vis-à-vis performance linked incentives

Generation based financial incentives are the most effective means of promoting and sustaining grid connected renewable energy projects. Within this mechanism, the utility purchases electricity from renewable energy developer, and pays a higher price than for electricity from conventional energy sources. The difference in prices could be made up either through cross subsidization, or through government subsidies. This mechanism rewards efficient performance and integrates renewable energy projects within the existing utility framework.

Support to develop capacity and capability rather than up front subsidy

A disadvantage of providing subsidy on the capital cost of the system is that there is no incentive for the manufacturer to affect such improvements/measures that reduce the cost of the equipment. This, in a sense, goes against the very idea for which subsidy was introduced in the first place. Essentially the aim of subsidization is to create large enough a market that can trigger commercialization by way of reduced system costs. One of the options could be to use these resources for the capacity building of the entrepreneurs, suppliers, and dealers etc. Compared to capital subsidy, this form may have an over all multiplier effect.

Subsidization to certain category of population

While the ultimate aim of any programme is to do away with the subsidies, in certain scenario, subsidies would continue to be provided. This is particularly true for those applications where otherwise the onus of services is on the government, such as:

- Subsidization of PV lanterns and solar cookers, for the weaker sections, rather than that of kerosene.
- Solar desalination systems for water deficient regions.
- PV pumps for drinking water supply.
- PV refrigerators for primary health centres and remote hospitals.

- Stand-alone power generation plant in an un-electrified and in-accessible village.

Moreover, exemptions should be provided in personal income tax to individual users of energy devices such as solar water heaters, cookers, and PV home lighting systems etc.

3.2.5.5. *Legal and Regulatory Interventions*

RET based electricity in regulated market and mechanisms to ensure renewable-based electricity procurement

In a number of countries, the utilities purchase renewable energy based electricity at prices higher than conventional electricity and pass this additional cost on to the customers who have opted for green power. Considering the fact that in a liberalized market, where ultimately competition would be for the least cost option, this mechanism may not be feasible.

As a consequence of the above, RET based electricity will require two essential elements, (i) a price support mechanism that enables renewable energy producers to enter the market and make a reasonable profit (ii) a stable regulatory environment that encourages RET based IPPs. One of the option could be to provide support to RET power by way of guaranteed prices, coupled with a purchase obligation by the utilities, as has been practiced in a number of countries (notably Germany, Spain and, at present Denmark).

Inclusion of externalities in pricing

Characterized by the non-internalization of external costs of energy production, costs of RET based power tend to be significantly higher than that of conventional power. But the cost of delivered power should be measured in terms of overall benefits associated with that form of power, and their implications. While a power producer may weigh an option purely on commercial basis, for the government it is important to consider all the relevant aspects. In such a scenario, RET based power outweigh the conventional power - on account their environment-friendliness and social implications of development. RETs have considerable advantage for isolated regions which are not sufficiently or are not at all connected to the grid. Use of RET electricity such places helps to avoid or delay expensive extensions to the grid on the one hand and ensure meeting the societal goal on the other hand. Furthermore, since these RETs are based on local resources, their propagation also helps in creating employment for the local population. This is especially the case for biomass.

Grid access to RETs, including wheeling and third party sales

Power evacuation set-up is extremely important for ensuring higher capacity factor and revenue generation from the project. Sometimes power evacuation network cannot cater to the installed capacity of the site (which is much more), leading to downtime.

The PPAs (power purchase agreements) with the state utilities for the sale of RET power is a crucial instrument on which the success of the project depends. Therefore, PPAs should be made for long term, without any ambiguity. There should be clear provision of cost escalation, to ensure financial viability of the venture. Similarly, there should be in-built safeguards against revocation of PPA.

3.2.5.6. *Rural Energy Interventions*

From the present supply-demand scenario, it is clear that biomass would continue to be the mainstay of the rural energy sector in the foreseeable future. The penetration of various commercial fuels will remain quite low, and at the present rate, it would take a long time for the RETs to make any significant impact on the sector. Therefore, any policy formulated to deal with rural energy will have to look for highly innovative options and make judicious investment choices. There are several issues to be considered while formulating such policies.

Technology choices

The principal thrust of any meaningful rural energy policy should be to effect a shift from the present *traditional* biomass technologies to *efficient* biomass technologies, which provide greater energy service with same resource. Presently, however, the choice of technologies available is quite limited and their impact is too low and slow. One of the reasons for this situation is the low priority attached to research and development. For instance, the investment made in the R&D of renewable energy technologies is just about 4.6 percent of the total expenditure of the MNES between 1982 and 1994 (Kishore, 1994). Therefore, developing a focussed and target-oriented R&D programme should be a top priority in developing and demonstrating the new technologies. The main objective of such a programme should be to come up with technologies that are low-cost as well as highly efficient, and suitable to meet local practices and lifestyles.

Dissemination approach

Most rural energy programs so far have been run as centralized, target-oriented programs exclusive of other programs. However, the experience suggests that while determining the feasibility or adaptability of a particular programme or technology, it would be important to consider the priorities of the local people, and bring about an integration of various development programs (TERI 1992). For instance, improved cookstove programme can be effectively combined with rural housing making it mandatory for all new government-constructed houses to install these devices as part of the design itself. Likewise, biogas dissemination can be done in conjunction with rural sanitation programs, solar photovoltaics with rural communication, etc. However, such an integration would be possible only if a decentralized planning method is adopted, and the local participation ensured[2].

Capacity building

Apart from the various aspects related to the planning and implementation of rural energy programs, the experience has shown that lack of adequate infrastructure and trained personnel at the operational level has led to several failures. Therefore, it is critical to develop this at the local level which could be done in two ways: (i) involve the NGOs at the grassroots level actively in planning, implementation and management of the programs; and (ii) develop rural entrepreneurship by initiating innovative fiscal and financial packages including access to soft credit[3]. Another opportunity is the involvement of local government bodies like *panchayats*. One of the initiatives undertaken by the Government in this regard is setting up of five Training-cum-R&D Centers in various parts of the country. The objectives of these centers are to conduct training courses for various target groups like professionals and staff working in the field of rural energy at the state, district and block levels including NGOs, beneficiaries and panchayats in various aspects of rural energy like planning, implementation, monitoring, extension and maintenance of systems.

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[2] In the Indian context, the following classification is suggested for decentralized rural energy planning: plan at the district level; programme, denoting a group of projects for a cluster of villages at the block level; and, project at the village level (Sinha, et al 1994).

[3] The turnkey entrepreneur approach used in the biogas programme has been quite successful in several parts of the country and could be a good model to adopt.

3.3. *Renewable Energy in China (ERI)*

3.3.1. Government Policy Directives

The central government has taken the following measures to promote renewable energy:

- In 1995 the Chinese Government promulgated the Electric Power Act. The act is the first Chinese law that discusses energy policy. In the first chapter (Introduction) it clearly states that China encourages the use of renewable and clean energy sources. Again in the sixth chapter (Rural Electric Systems Construction and Agricultural Sector Electric Supply) it emphasizes that China wants to develop water resources in rural areas and promote small hydropower systems for rural electrification. The deployment of solar energy, wind, geothermal, biomass, and other renewable energy resources will be encouraged and supported by the government.
- The Guidelines of the Ninth Five-Year Plan and 2010 Long-Term Objectives on Economic and Social Development in China, approved by the Eighth National People's Congress, have become the primary guidelines for the Chinese government in energy development. Both stress that electric power development will be the core task of China's energy development and coal will be the fundamental energy resource. The guidelines also call for strengthening the explorations of oil and natural gas, actively developing new and renewable energy resources, and improving energy infrastructure. For rural electric development, the guidelines emphasize the importance of small hydro, wind, solar energy, geothermal, and biomass resources and that the development strategies should adapt to local conditions.
- In 1996 the Ministry of Electric Power (MOEP) issued the "Parallel Operation Regulations for Wind Power Generation." They require that the power grids must allow interconnection and parallel operations of wind farms, and that the power grids must buy all electricity generated by the wind farms. It further specifies that the purchase price should include production cost, repayment of debt and interests, taxes, and a reasonable profit. The difference in prices between the wind energy and the average market price should be borne by all the customers of the power grid, not just the customers closest to the renewable energy projects.
- The 1998 Energy Conservation Act again recognizes and emphasizes the importance and strategic role of using renewable energy to reduce emissions and to protect the environment.

3.3.1.1. Economic Incentive Policies

Import duty reduction

Import duty reduction is one of the most direct economic incentives offered to renewable energy development by the Chinese government. China has adjusted the import duty several times in the past few years to bring the overall import duty level compatible to that of the most of the countries in the world. The average import duty now stands at 23 percent, but renewable energy technologies enjoy special low rates: of 3 percent for components of wind power plants, 6% for wind turbines, and 12% for PV systems.

Reduction in value added tax

The rate of value added tax (VAT) is 17 percent. Although not all renewable energy technologies enjoy reduced VAT rate, two of them do. VAT for biogas is only 3 percent, and VAT for small hydro is only 6 percent.

Reduction in income tax

The income tax is collected by local governments. Currently the corporate income tax rate is 33 percent. Governments of several provincial and autonomous regions have initiated special low income tax rates to encourage the development of renewable energy technologies (see table in Annex 2).

Favorable purchase pricing

In addition to the pricing policy for wind energy established by MOEP in 1996, and confirmed by SDPC (State Development Planning Commission) several local governments have decided to establish special favorable purchasing prices for electricity from renewable energy sources. For example, the municipal government of Shanghai has set special price for biogas for household cooking.

Low interest loans

Chinese government has established specific low interest loans for rural energy development since 1987. The primary targets for these low interest loans are large and medium biogas projects, solar energy applications, and wind technologies. Interest rate of low interest loan is only half of that from a comparable commercial loan. The amount of low interest loans was 120 million RMB in 1996. In addition, China also establishes special low interest loan programs for small hydro projects.

Subsidies

Subsidies are often provided by the Chinese government to support renewable energy technologies. Subsidies provided by the central government usually support research, development and demonstration projects. Local governments also subsidize renewable energy development through price reduction of raw material For example, Sichuan and Guangdong provinces offer special low prices for cement to be used to construct biogas facilities.

3.3.1.2. Government Supported Research and Development (R&D)

Central government supports renewable energy by establishing R&D strategy and plan for the renewable energy industry and funding many R&D projects directly. R&D initiatives include the following three major areas:

- Support to various renewable energy research institutes and research projects;
- Specification of targets for improvement in renewable energy technologies performance and provision of necessary training. Incomplete figures suggest that more than 100 million RMB will be used for this purpose during the Ninth Five-Year Plan.
- Subsidies to renewable energy demonstration projects. For example, the central government invested 7 million RMB in four PV generation stations (total capacity 85 kW) during the Eighth Five-Year Plan.

3.3.1.3. Market Development Policy for Renewable Energy

Implementing renewable energy market development activities is just beginning in China. One approach used by the government was the establishment of a revolving loan fund to support the renewable energy applications. For example, the municipal government of Shanghai has created a 10 million RMB revolving loan fund to advance biogas applications within the city limit.

China also starts initiatives to reform business practices as a means of reducing non-financial barriers for renewable energy development. For example, the State Development and Technical Commission organized a call for proposals and awarded the contract for a polycrystalline thin-film PV manufacturing facility. This activity, including the bidding process, was carried out within the Ninth Five-Year Plan targeted technology improvement program. A recent project on an anaerobic treatment plant for urban waste water in Yiwu Xian, Zhejiang Province employed a similar bidding process to award the final construction contract. Reforming business practices can result in lower cost and higher quality renewable energy projects.

3.3.1.4. Local Government Incentive Policy

Besides the central government, the local governments are also developing some incentives for renewable energy. Annex 1 summarizes the policies enacted by the local governments in China.

3.3.2. Policy Recommendations for Promoting Renewable Resources of Energy in China

Substantial reasons exist for China and international bodies to promote and foster the use of renewable energy when it meets the test of improving the welfare in China. Some reasons that renewable energy may deserve special promotion are provided below, followed by suggested options for promoting increased renewable energy supply and funding public expenditures for this purpose.

3.3.2.1. Reasons for Promoting Renewable Energy

Environmental externalities

The environmental externalities associated with coal use for energy are very large. The damages avoided when clean renewable energy is substituted for coal are benefits that are not reflected in the price paid for such energy. These benefits flow to the citizens of China and, to some extent, the rest of the world. Public expenditures are justified to promote renewable energy to the extent that they result in these benefits, that is, of reducing the environmental damage from the coal that is displaced. Beyond these benefits, renewable energy often has positive externalities based on specific applications at specific places. Biogas production as a means of increasing effluent cleanup from industrial operations is one example. Reduction of air pollution from open burning of crop residue or forestry waste is another.

Development of remote areas

The classes of benefits include increased social stability and equity, reduced population growth, reduction of emigration to urban areas, reduced environmental damage, improved health, and increased productivity. Renewable energy is often the least-cost method for increasing remote area energy supply. Public expenditures to promote renewable energy in remote areas are justified to the extent that they cost-effectively increase energy supply and thereby bring these gains to China in general as well as to citizens who benefit directly.

Development of the renewable energy industry

The renewable energy industry is in its infancy. Its costs are now above the long-run equilibrium level, and will not fall unless and until the industry reaches a larger scale. The industry also needs an opportunity to refine and adapt the technologies best suited to each location and to develop the necessary cadre of skilled workers and managers. Full maturity also requires that it develop the necessary institutional structure and policies and achieve consumer acceptability. Public support that assists the industry to reach this level, or that shortens the path, will yield lower energy costs in the future. It will also hasten realization of other renewable energy benefits in China. Public expenditures to help the renewable energy industry mature are investments that will yield future benefits. These expenditures are justified now to the extent that they produce such returns.

Insurance against future risks

Renewable energy can contribute to helping China reduce the risk of future energy problems. One category of risk is the possibility that China will need to make major reductions in CO2 emissions.

Still another category is future demand by the citizens of China for a much cleaner environment. It is possible that adequate environmental quality will be inconsistent with the level of coal combustion needed for continued economic growth. Renewable energy would provide a bulwark against falling output of goods and services. Finally, renewable energy is a geographically dispersed source of power and has characteristics different from those of the alternatives.

3.3.2.2. Options for Promoting Renewable Energy

Standard offer contracts

Standard offer contracts is the term used for agreements by which an electricity grid purchases power from a source at a given price – normally the avoided cost of the energy displaced, including the capacity cost for making it available. Such contracts provide the necessary market guarantee for investment in renewable energy facilities and are powerful mechanisms for reducing the institutional barriers that inhibit development. Just as important, they are mechanisms that use market forces to ensure that renewable energy facilities are least-cost sources of power and are operated efficiently. Therefore, they maximize the contribution to national welfare by eliminating the bias against renewable energy without replacing it with incentives to use this form of energy when not in the national economic interest to do so. Substantial, highly positive experience with such policies exists in the United States and other countries. To gain the incentive effects of standard offer contracts, China government would have to mandate their use by the electricity grids.

Portfolio standards

Portfolio standards is the term used for a government requirement that electricity grids obtain a certain percentage of their power from renewable energy. This is a powerful tool to bring renewable energy to market but, unlike standard offer contracts, can lead to unjustified increases in the cost of electricity and to reductions in national economic welfare. This is because portfolio standards can cause investment in and production of renewable energy that is more expensive than alternative energy. Further, because the renewable energy supplier is not required to meet a market test, there is less incentive for production to be as efficient as possible. These problems could be particularly severe in China. Portfolio standards have been adopted in some countries, but they do not appear to be desirable as a part of China strategy.

Green power

Green power is the term used situations in which purchasers of electricity can choose to consume renewable energy, and the grid certifies that the equivalent kilowatt-hours delivered to those who prefer green power are produced from renewable sources. The cost to the grid of green power may exceed the cost of other electricity, but the market demand from willing consumers provides an incentive to the grid to buy renewable energy at higher cost. Green power has been successful in promoting renewable energy in limited circumstances in the United States and elsewhere. Consumers have been motivated by environmental concerns to voluntarily pay a higher price for the power, and could afford to do so because of relatively high incomes. Green power does not seem to be a practical option in China for institutional, economic, and cultural reasons.

Green dispatch

Green dispatch is the requirement whereby grids must take all power available from renewable energy sources before taking power from other sources. The demand or "load" varies on a grid. Under usual circumstances, the managers of power supply take the least-cost sources of power first, and only as load rises do they start producing and taking power from higher-cost facilities. Green dispatch requires grid managers to prefer green power to the cheapest power in their dispatch decisions.

This provision can be extremely important in promoting renewable energy. Many renewable energy technologies, such as co-generated electricity from sugar mills, are either highly capital intensive or produce energy as a by-product of other activity whose timing cycle is independent of electricity demand. To be economical, such sources must be able to sell their full production as and when it is produced. Green dispatch ensures such a market, and thereby provides the needed incentives and guarantees enabling renewable facilities to be built. Properly utilized, green dispatch can contribute to achieving minimum grid long-term incremental cost - but this requires that the grid sometimes purchase electricity from renewable sources at prices higher than the minimum short-term incremental cost.

Green dispatch can play an important role in promoting renewable energy in China. It can be implemented either in a directive to the grids or through an appropriate provision in national requirements for power purchase agreements.

Standards and codes for thermal buildings

Design standards for the solar components are necessary to provide interchangeability, ready application in dispersed locations and conditions, and a basis on which the construction industry can rely in the design and construction of the building and support structures. Minimum performance standards in terms of durability, reliability, and thermal performance are necessary both for the construction industry as it employs the devices and for commercial penetration.

Fossil energy taxes

As noted above, fossil energy production, conversion to electricity and heat, and use imposes external costs on China, mostly in the form of environmental damage. This has caused some observers to recommend that China impose a tax on fossil fuel use or on some measure of the damage it causes. The SO_2 tax is an example of such a tax. A tax on fossil fuels would raise their price and promote renewable energy by reducing the distortion that now exists because fossil fuels do not pay their full social costs.

Technical infrastructure development

China lacks an adequate technical infrastructure to achieve the expansion of renewable energy justified by its potential contribution to total welfare. This infrastructure will not develop at a sufficient pace unless it receives additional support. This support must come from policy action. Among the components of the needed technical infrastructure is technology transfer from abroad. Also needed is additional domestic R&D both to develop new sources and to adapt those that already exist to CHINA conditions. Design and engineering institutes with which local organizations can contract to plan and manage construction of appropriate facilities are inadequate to the task in number and experience. Finally, sufficient skilled and trained workers to construct, operate, and maintain facilities are not available and will require special recruitment and training.

Financial support for renewable energy

Direct financial support for renewable energy is another option for promoting them. However this is arranged, support that makes welfare-enhancing renewable energy possible must be distinguished from subsidies. The former is designed to redress imbalances between renewable energy and fossil energy and overcome the financial barriers that prevent otherwise economic renewable energy from being developed. Subsidies, in contrast, could promote renewable energy facilities excessively and tilt the energy system too far in the renewable direction to the detriment of overall economic efficiency and welfare.

3.3.2.3. Sources of Funding for Promotion of Renewable Energy

Fossil fuel tax

A fossil fuel tax was discussed above in terms of its incentive effect in eliminating the bias against renewable energy. Such a tax would also effectively and economically raise revenue that could be used for other programs to promote renewable energy.

Consumers of renewable energy

One option for funding the promotion of renewable energy is to charge the consumers more than they would otherwise pay. This happens when grids are required to buy renewable power at greater than avoided costs, for example, under a portfolio standard approach. This mechanism is used to provide support for wind power under the existing Chinese policy. It is most effective and least objectionable when the extra costs of the renewable energy are small in comparison with the total revenues of the electric grid, and therefore represent a small incremental charge to consumers.

In effect, this approach "taxes" consumers of renewable energy to provide funds to support a program that brings greater or lesser benefits to all Chinese citizens. In one sense it is not equitable, which is one of its disadvantages. Another disadvantage is the incentive it gives the grid and its consumers to avoid installing or agreeing to purchase renewable energy, creating a barrier against ultimate success. On the other hand, it is simple and inexpensive to add the costs of support to renewable energy to the cost of electricity. It is therefore an easy and cheap tax to collect.

All electricity consumers

Current production of renewable energy and the future development of the renewable energy industry can be thought of as benefiting all present (and future) electricity consumers, not just those who happen to obtain some kilowatts from such sources. For this reason, one attractive option for gathering funds for renewable energy development would be a surcharge on all electricity consumption to create a government fund for this purpose. This device is currently used in China to provide some of the funds to support the Three Gorges project.

A special issue identified in this report is the need for energy support for remote areas. Enhanced energy supplies in remote areas will contribute directly to the welfare of people in the developed part of the country. A surcharge on all electricity consumed would be a fair and efficient way to gather the funds required for a remote areas energy program. A similar argument can be made for the broad-based tax on fossil fuels described above.

General government revenue

Increased renewable energy, development of remote areas, and relief of poverty through enhanced energy supplies are goals of China because they will contribute to the current and future welfare of the country. Such expenditures are part of the usual and appropriate role of government and, as one option, can be funded by general government revenues.

3.3.3. Lowering Barriers to Renewable Energy Development

Reducing transactions costs

Transaction costs are a strong barrier to renewable energy development for two reasons. First, renewable energy projects are typically much smaller than fossil fuel projects. Many transaction costs are essentially "fixed." That is, they are roughly the same for a small project as for a large one. Therefore, the transaction cost per unit of energy produced from renewable energy projects are typically much higher than for fossil plants, creating a competitive disadvantage. Second, renewable energy projects typically are more complex in organization and in relationships to the grid than are individual fossil fuel plants. They require agreement among more parties, involve either multiple products or are fueled by by-products, and have broader connections with other aspects of community economic, social, and development affairs. Therefore they inherently involve more complex analyses and negotiations. Institutional reforms should be directed at lessening both of these disadvantages. The most effective mechanism for reducing transaction costs is to standardize the analyses used to determine project desirability and the basic terms of agreements and contracts to implement them. Reforms underway in China will contribute greatly to this goal by reducing the number of government units and defining their responsibilities more precisely, decentralizing decision-making, and increasing the role of written policy and law.

Expediting power purchase and similar agreements

The PPA sets the terms by which power is marketed and/or exchanged. It establishes the delivery location, power characteristics, price, quantity, schedule, length of the agreement, and penalties for failure to meet contractual terms, among other items. Two systemic institutional barriers exist in creating PPAs. First, the off-taker holds substantial market power over the producer, and second, negotiations over terms are inherently complex and expensive. An institutional remedy to lessen these barriers would substantially improve China's ability to make effective use of renewable energy. The market power issue is simple: the utility grid has many potential alternative sources of power, but the renewable energy producer is totally dependent on the grid for its market. Under these circumstances, the result of negotiations can be predicted: the grid will pay *at most* the avoided cost of power from alternative sources. Further, each renewable energy producer will be forced to accept a price that is *no more* than its minimum cost of production, without extra profit. To maximize its position, the grid will seek to negotiate separately with each renewable energy producer and will pay each a different price. Thus one result of the grid's market power is to increase the number, complexity, and contentiousness of negotiations with renewable energy producers and add to the uncertainty of the result.

Further, once the renewable energy facility is built, the grid will seek to renegotiate the contract terms further in its favor. Because the capital costs of the facilities will be sunk, the grid will be able to press for a price that no more than covers the producer's variable costs. Its weapon in forcing re-negotiation is threatening to reduce its off-take of power, thereby reducing the revenues of the producer. Thus, another result of the grid's market power is greater financial risk for the renewable energy facility, even if it is a technical and cost success in meeting its planned operating goals.

Creating responsive financial arrangements

The requirements for financial institutions to support renewable energy as outlined above appear formidable. However, these functions are handled smoothly and at reasonable cost in mature Western economies, and therefore ample models exist. Given the rapid reform of Chinese financial institutions and the commitment of provincial and central governments, there is no reason that these requirements cannot be met. Setting up these arrangements will be a key component in expanding the scope and benefits of renewable energy. Efforts to do so by the ministries and agencies responsible for energy, sustainable development, national planning, financial administration, macro-economic control, and the alleviation of poverty, among others, are a high priority.

3.3.4. Policy Directions to Foster Renewable Energy in China

China does not now have in place policies and institutions that allow renewable energy to make its full contribution to economic, environmental, and development goals. The range of required actions is large, and needed reforms fall within the areas of responsibility of numerous agencies of China. Moreover, such reforms are often intertwined with other activities of these agencies and cannot be separated out for special attention. For example, remote area energy cannot be separated from poverty alleviation, and taxes on fossil fuels to offset environmental externalities cannot be considered distinct from fiscal policy or environmental regulations. This means that it is unlikely that accomplishing appropriate reform can be assigned to one organization with good prospects for success.

What is needed is a coordinated attack on the problem that takes advantage of opportunities for action that exist in various bodies, and takes into account their other responsibilities and constraints. The starting point for such an attack would be the realization by CHINA leaders that enhancing renewable energy would contribute to economic, environmental, and development goals. If renewable energy were raised to a position of policy priority, existing government bodies could be motivated to take the actions required. Coordination and monitoring of results could be accomplished by a secretariat reporting to the State Council, operating in the same manner as, for example, the Poverty Alleviation Office.

Creation of a new government body is the alternative to mobilizing existing agencies. This approach has advantages. First, it would place responsibility in a single body, ensuring accountability. Further, this body could develop expertise and provide a single point of contact for international organizations. On the other hand, it would require creation of a new bureaucracy that, moreover, would need to reach all corners of the country to be successful. Further, programs and policies for the most part would still have to be executed through other bodies and ministries. This would separate decisions about what should be done from those responsible for doing it, a situation that creates tensions and obstructionism at worst and high administrative and coordination costs at best. Given that it has embarked on a vigorous effort to reduce the size of government, China is unlikely to create a new organization when existing bodies can perform the task as part of their normal operations.

On balance, creation of a new renewable energy agency seems neither desirable nor plausible. Therefore, China's policy efforts to foster renewable energy should be left in the hands of existing ministries and organizations, perhaps with the addition of a secretariat reporting to the State Council with the task of coordinating and promoting appropriate policies by other government agencies. This secretariat could also be given the responsibility of representing the fiscal requirements of renewable energy in determining budget allocations.

4. Policy Implications

Based on the results of the study, a range of policy-relevant findings were discussed at the workshops with Asian experts:

1. The study revealed that in both India and China there exists a large potential for renewable energy. However, the business-as-usual energy policies do not fully utilize this potential due to cost considerations and a variety of institutional barriers. It was found that by the year 2020 with maximum policy interaction the use of renewable energy could be increased in China by 67 percent and in India by 57 percent.
2. Continuing economic development will result in increased energy demand in Asia. It has to be expected that growing use of conventional fossil fuels will cause a range of environmental problems, *inter alia* increased emissions of greenhouse gases and sulfur dioxide. In order to maintain acceptable environmental conditions and safe levels of air quality in the future, the increased use of conventional fossil fuels must be accompanied by strict emission controls (e.g., desulfurization). The costs of such emission controls will make the utilization of conventional energy more expensive and thereby lead to an increased competitiveness of renewable energy.
3. As a result of the project, a practical tool for a systematic assessment of the cost-effectiveness of sulfur emission control strategies is now available for Asia.
4. The optimization feature of the newly developed assessment tools enable local planners to find least-cost emission control strategies that achieve given environmental objectives, specified, e.g., in terms of local air quality or sulfur deposition. The cost-minimization concept identifies the least-cost combinations of the emission control measures that are available at the various emission sources in the various economic sectors.
5. While the optimization assists in identifying cost-effective allocation of emission controls, the selection of appropriate environmental targets is a policy choice that has to balance the ability and willingness of societies to spend money on emission controls against the acceptance of damage to human health and the environment.
6. It has been demonstrated that, for a given set of environmental targets, an increased use of certain forms of renewable energy costs could reduce the necessary costs for controlling emissions by about 20 percent. This applies particularly to (small and large) hydro power plants and wind mills for electricity generation, enhanced use of biogas also in industry and solar thermal, geothermal and use of dung in the domestic sector. If the potential for renewable energy could be further increased by appropriate policy measures, additional cost savings could be harnessed.
7. However, in a business as usual strategy important barriers prohibit the full use of renewable energy. Some of these barriers are of technological nature, e.g., that the technologies for utilizing renewable energy are not fully developed or that present technologies do not fully respond to the needs of users. There are also important economic barriers, such as high initial costs of new technology options, higher investments compared to conventional energy so that, when capital is scarce, users experience financing problems, and the distorted price structure of conventional energy that prevails in both countries. Also a range of institutional barriers hamper the full utilization of the physically available potential of renewable energy in India and China: Renewable energy is best utilized in decentralized systems, while conventional energy supply is centrally organized. There are difficulties to fully access the market for renewable energy technologies, and many potential users of renewable energy lack the necessary awareness about the benefits that renewable energy could offer to them.

The workshop participants recognized the potential role of renewable energy in implementing cost-effective emission control strategies and identified a number of policy recommendations that should help to overcome the barriers that presently prohibit the full utilization of renewable energy in India and China. In particular, policy interaction should support

- technology development to produce technologically mature systems that utilize renewable energy fully responding to the needs of the users,
- financing mechanisms to overcome the high investment burdens of renewable energy,
- the implementation of simplified project clearing mechanisms to reduce the administrational burden for constructing facilities for renewable energy,
- the development of markets for renewable energy technology and the facilitate access to these markets, particularly in rural areas,
- awareness raising about the benefits of renewable energy, particularly among rural population,
- appropriate incentive mechanism to foster the use of renewable energy. It will be important that such incentives focus on the actual performance of renewable energy systems instead on the pure construction of equipment, so that users are motivated to care about the actual operation of the infrastructure.
- human capacity building as one of the key fields for policy interaction,
- appropriate accounting systems so that existing price distortions of conventional energy are removed and users see the real costs of the various energy forms. It will be important to account for the external costs of conventional energy.
- legal frameworks facilitating the grid access of renewable energy.

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6. Annex 1: Proceedings of the Policy Workshop Beijing, 9 -10 May 2000

Programme of the Workshop on

The Role of Renewable Energy in Air Pollution Abatement in Asia

8 - 10 May 2000, Beijing, China, Energy Research Institute (ERI)

Day 1, 8 May 2000

19:00	Dinned for foreign workshop participants hosted by ERI

Day 2, 9 May 2000

8:45	Registration

Opening

9:15 -10:00	Welcome addresses -
	Zhou Fengqi, Director of Energy Research Institute, Beijing , China
	LI Baoshan, Deputy division chief, Energy and Transportation Division of MoST
	Prof. Leen Hordijk, WIMEK, Wageningen, The Netherlands

Session 1: Overview of the objectives of the workshop and main results

Chair: Prof Li Jungfen, ERI, Beijing

10:00 - 10:40	Objectives of the Workshop and contributions of the Potential for Use of Renewable Energy Project and the NOP Asian Dilemma Project to these objectives
-	Prof. Leen Hordijk, WIMEK, Wageningen, The Netherlands
-	Dr. Joyeeta Gupta, Institute for Environmental Studies, Amsterdam, The Netherlands
10:40 - 11:00	Break
11:00 - 11:45	Cost-effectiveness of renewable energy technologies in controlling SO_2 emissions, Dr Carolien Kroeze, WIMEK, Wageningen, The Netherlands
11:45 - 12:30	Integrated assessment of the role of renewable energy in SO_2 and CO_2 abatement in China and India: summary of scenario runs, Dr. Markus Amann, IIASA, Laxenburg, Austria

Session 2: Potential for renewable energy in India and China and policies

Chair: Dr. Markus Amann, IIASA, Laxenburg, Austria

14:00 - 14:40	Review of current policies on renewable energy in the IEA countries, Prof. Li Jungfeng, ERI, Beijing
14:40 - 15:20	Potential for use of renewable energy till 2020 and policies in India, Dr. Amid Kumar, TERI, New Delhi, India
15:20 - 15:40	Break
15:40 - 16:20	Potential for use of renewable energy till 2020 and policies in China, Prof. Li Junfeng, ERI Beijing
16:20 - 17:20	Demonstration of RAINS-ASIA software, Dr. Janusz Cofala, IIASA, Laxenburg, Austria
17:20 - 18:00	Discussion
19:00	Reception and dinner hosted by ERI

Day 3, 10 May 2000

Session 3: The Asian Dilemma Project - Overview and Main Findings

Co-chairs: Prof. Li Jungfeng ERI, Beijing, China, and
Prof. Dr. Leen Hordijk, WIMEK, Wageningen, The Netherlands

9:00 - 10:45	Overview of the Project and main findings

Session 4: Asian Dilemma Project: Opportunities and barriers for implementation of greenhouse gases reduction options for electricity production and use (parallel discussions)

11:00 - 12:30	Discussions in subgroups

Session 5 Conclusions and Recommendations

Chair: Prof. Li Jungfeng

14:00 - 15:00	Report on the Asian Dilemma Project's subgroup discussions (by rapporteurs)
15:00 - 15:20	Main findings and conclusions from the Potential for Renewable Energy Project, Dr. Markus Amann, IIASA, Laxenburg, Austria
15:20 - 15:40	Main findings and conclusions from the NOP Asian Dilemma Project, Dr. Joyeeta Gupta, Institute for Environmental Studies, Amsterdam, The Netherlands
15:40 - 16:10	Discussion
16:30 - 17:00	Concluding remarks and closing, Prof. Dr. Leen Hordijk, WIMEK, Wageningen, The Netherlands

List of participants

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7	Amit Kumar R Nigam		Tata Energy Research Institute
8	Sujata Gupta		Tata Energy Research Institute
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7. Annex 2: Economic Incentive Policies of Local Governments in China

Region	Subsidy Policy	Taxation Policy	Price Policy	Loan Policy	Other Policies
Inner Mongolia	(1). (1986-1990) subsidies to customers: 200 Yuan per set of 100 W wind power system or 16W PV system; total subsidy of 25.0 million Yuan from government funds. (2). 300,000 Yuan annual grant to support research and development. (3). Rural energy office branches established in 56 counties, with government funds	(1). Additional VAT for wind power, reduced from 8% to 3% (2). Two years income tax exemption for renewable power producers (3). VAT surtax on PV of 10.69-14.43 Yuan/16Wp-21.6Wp Wp is peak Watt, which used for solar PV capacity calculation. Usually, the VAT is about 17% of the sales price. For example, 16 Wp syatem, the sales price is around 660 Yuan and the VAT is about 112 Yuan, as the incentive, the VAT for PV system is only 10.69 Yuan, which means about 100 Yuan VAT was reduced in this region.	(1).Purchase price of wind power in 1995: 713 Yuan/MWh (including VAT), 609 Yuan/MWh (net of VAT) (2). Incremental price (extra cost of renewable electricity) shared between the grid and the consumer; grid bears 200 Yuan/MWh, remaining part subsidized through a surcharge on electricity tariff of 2.5 Yuan/MWh	(1). 400 million Yuan has been arranged by SETC to support the wind power. (2). Loan from the Government of the Netherlands was given by SPC to support wind power.	Policy on land use: (1). Land tax imposed on land really occupied (2). Exemption from income tax for the cultivated land user for 5 years (3). Exemption from land tax for 10 years for those using uncultivated land
Xinjiang	(1). Subsidies for expansion projects: subsidy to PV systems, small size wind power systems of 50-200 Yuan/system. (2). Subsidies for R&D: over 1.0 million Yuan each year (3). Support institutional capability development, provision of overhead to most rural energy office at county level. (4). Subsidies to consumers using the PV systems (300 Yuan or 10% of the cost of set)	(1). Wind power: foreign owned installations or joint ventures with 10 or more years operation enjoy tax exemption for the first 2 years, and tax reduction for the succeeding 3 years; for the remaining 5 years the tax rate is 15%. VAT exempted if product exported. ((2) PV system: International donations are exempt from import duty and VAT; others purchase 12% duty and 17% of VAT..	(1). Purchase price in 1995, 698 Yuan/MWh (including VAT); the price of grid electricity is 1180 Yuan/MWh. (2). Extra cost of renewable electricity was shared between the utility and the consumer. The government agreed that the sales price of electricity increased 200 Yuan/MWh and 50 Yuan/MWh for cover the part of extra cost of renewable electricity. The rest extra cost was covered by utility itself.		Wind power: charges on land use collected according to the area really occupied.

Region	Subsidy Policy	Taxation Policy	Price Policy	Loan Policy	Other Policies
Gansu	(1). Subsidies for the extension of PV systems: sun light fund established (subsidy 300 Yuan/set). (2). Subsidies for R&D of PV systems (3). Subsidies for the establishment of technical supporting institutions	Taxation policy on PV system is similar to Xinjiang. only the monthly VAT rate of non grant PV system is 25% PV system International donations are exempt from import duty and VAT; others purchase 12% duty and 25% of VAT		PV systems: county governments offer loans for solar PV household system with preferential interest rate 3%. Preferential rates financed from additional fee on electricity of 3 Yuan/MWh and from government finance (20 % of total).	Policy on land use: (1). Land tax imposed on land really occupied (2). Exemption from income tax for the cultivated land user for 5 years (3). Exemption from land tax for 10 years for those using uncultivated land
Qinghai	(1). Subsidies for the extension of PV systems (300 Yuan/set). (2). R&D: more than 500,000Yuan annually to support Qinghai New Energy Research Institute. (3). Support institutional capability development, provision of overhead to most rural energy office at county level.		Additional fee of 2 Yuan/MWh imposed; revenues from that fee partly used to support the consumers to install PV system (total support - 900 thousand Yuan/year)		Wind power: charges on land use collected according to the area really occupied.
Northeast grid		Two methods are available for renewable electricity; 1. Reduce VAT rate from 17% to 6%; or 2. High purchase price, such as in Hengshen wind power, the purchase price is 900 Yuan/MWh or 110US$/MWh.	Payback price system: The purchase price will be calculated to cover the investment, operating cost and plus the reasonable profit of the developer. Same at below.	Preferential loans for wind power	Land tax is collected according to actual areas occupied by wind turbine, and to treat wind power enterprise as foreign fund enterprise
Guangdong		The VAT collected at 20 Yuan/MWh; the income tax collected at 51% of the original income tax	The purchase price was calculated as 770Yuan/MWh and the extra cost of renewable electricity fully paid by consumer.		
Zejiang			Cost-recovery pricing of renewable electricity connected to the grid.		

8. Annex 3: Major Renewable Energy Programs in India

A. Solar Thermal Programme

The principal objective of the Solar Thermal Programme being implemented by the Ministry of Non-conventional Energy (MNES) is market development and commercialization of solar thermal systems, such as solar water heaters, solar cookers, solar air heaters/dryers etc. for meeting thermal energy requirements for different applications in the domestic, commercial and industrial sectors of the country. Programme components include:

1. Promotion of Solar Thermal Technologies through soft loan programme.
2. Solar Cooker programme for market development and commercialization of solar cooking devices.
3. Solar Buildings programme for training & education, awareness creation and also for providing assistance for design and construction of solar buildings.
4. Regional Test Centres and Technical Back-up units for solar thermal devices and systems.
5. Research & Development programme for development of new and emerging technologies and improvement of available technologies.
6. Establishment of Solar Shops in major cities & towns of the country for on the spot sale of renewable energy products, servicing and information dissemination.

Soft loan programme on solar water heaters through commercial banks

Terms of Loan to consumers

<table>
<tr><td>Capacity</td><td colspan="2">Up to 2000 litres of hot water at 60-80 C per day</td></tr>
<tr><td>Loan amount</td><td colspan="2">85% of the ex-factory ex-showroom cost of the system</td></tr>
<tr><td>Interest rate for soft loan</td><td colspan="2">5% per annum</td></tr>
<tr><td>Loan repayment period</td><td colspan="2">5 years</td></tr>
<tr><td>Repayment starts at</td><td colspan="2">3 months after the release of funds to the consumers</td></tr>
<tr><td>Penalty for defaulted loans</td><td colspan="2">For defaulted loans banks may charge penal interest @ 2% over and above the stipulated interest rate</td></tr>
<tr><td>Eligibility for loan</td><td colspan="2">Any individual, institution, association, business establishment, etc</td></tr>
<tr><td>Eligible suppliers</td><td colspan="2">Suppliers of solar water heats with BIS (Bureau of Indian Standards) approved solar collectors</td></tr>
<tr><td colspan="3">Upper limit of cost solar water heating systems to be financed by banks (for guidance only)</td></tr>
<tr><td>System with collector area</td><td>Approximate capacity</td><td>Cost</td></tr>
<tr><td>1 no. collector system (2 sq.mt.approx)</td><td>100 litres</td><td>Rs 18,000</td></tr>
<tr><td>2 nos. collector system (4 sq.mt.approx)</td><td>200 litres</td><td>Rs 35,000</td></tr>
<tr><td>3 nos. collector system (6 sq.mt.approx)</td><td>300 litres</td><td>Rs 50,000</td></tr>
<tr><td>4 nos. collector system (8 sq.mt.approx)</td><td>400 litres</td><td>Rs 65,000</td></tr>
<tr><td>5 nos. collector system (10 sq.mt.approx)</td><td>500 litres</td><td>Rs 80,000</td></tr>
<tr><td>6 nos. collector system and onwards upto 20 nos. collector system sq.mt.approx)</td><td>600 litres</td><td>Rs 14,500 for each collector</td></tr>
<tr><td>i.e. for 10 nos. collector system (20 sq.mt.approx)</td><td>1000 litres</td><td>Rs 1,45,000</td></tr>
<tr><td>For 15 nos. collector system (30 sq.mt.approx)</td><td>1500 litres</td><td>Rs 2,17,000</td></tr>
<tr><td>For 20 nos. collector system (40 sq.mt.approx)</td><td>2000 litres</td><td>Rs 2,90,000</td></tr>
<tr><td>Maintenance guarantee</td><td colspan="2">Suppliers will be responsible for maintenance of the systems for 5 years and it will form part of unit cost to be financed by the banks as per above guidelines</td></tr>
<tr><td colspan="3">The cost indicated above includes the cost of collector, insulated hot water storage tank, system piping, instrumentation, controls etc. The cost also includes maintenance responsibility of the systems by the manufacturers for five years. The bank will provide 85% of the cost of the system as soft loan.</td></tr>
</table>

Financial Incentives

Technology	**Implementing organisation**	**Category of end-user**	**Rate of Interest**
Solar water heating system (upto 2000 litres capacity)	Banks/HUDCO etc	Individual, institution, association, small business establishment	5% (to end user)
Solar water heating system (upto 2000 litres capacity)	IREDA (through financial intermediaries). IREDA provides loans to financial intermediaries @ 2.5% rate of interest	Individual, institution, association, small business establishment	5% (to end user)
Solar water heating system (any capacity), solar air heating system, solar desalination system, solar swimming pool	IREDA (direct or through financial intermediaries)	Institutions, trusts, charitable organizations etc (non-profit organizations)	5%
Solar water heating system (any capacity), solar air heating system, solar desalination system, solar swimming pool	IREDA (direct or through financial intermediaries)	Industry, hotels and other commercial organisations (profit making)	8.3%

Fiscal Incentives

Sales Tax

Exemption/reduction in Central sales tax and general sales tax are available on sale of renewable energy equipment in various states

Indirect taxes:

Customs duty
Solar thermal
(a) Vacuum tube solar collectors, concentrating solar collectors
Plastic collectors or Stirling engines for manufacture of solar energy equipment 10%
(b) Linear actuators for tracking systems, Fresnel Lenses or Sun sensors, for manufacture of concentrating solar collectors 10%
(c) All goods, imported by a manufacturers-supplier for the 10% manufacture and supply of machinery and equipment to a power generating plant (other than captive power generating plant) 10%

Direct taxes:
(a) Accelerated depreciation on specified non-conventional renewable energy devices/systems in the first year of installation of the projects: 100%
(b) Tax holidays on renewable energy power projects: 5 years

B. Solar photovoltaics Programme

A countrywide Solar Photovoltaic Programme is being implemented by the Ministry for about last two decades. The programme is aimed at developing the cost effective PV technology and its applications for large-scale diffusion in different sectors, especially in rural and remote areas. Major components of PV programme include R&D, demonstration and utilization, testing & standardization, and promotional activities. The following PV systems are covered under the programs of MNES:

1. Solar Street Lighting Systems, Solar Lanterns, Home Lighting Systems/Solar Home Systems
2. Stand-alone PV Power Plants
3. Solar PV water pumping systems for agriculture and related uses
4. Other applications of PV Technology including new applications

Industrial and promotional activities

A sizeable industrial base for production of solar cells, PV modules and systems has been established. There are 9 manufacturers of solar cells, 22 manufacturers of PV modules and about 45 manufacturers of PV system and components. During the financial year 1998-99, about 6.5 MW solar cells and 9.5 MW PV modules were produced. India is the third largest manufacturer of single crystal silicon cells in the world. During 1998-99, more than 3.5 MW of PV products were exported.

Industrial policy

The Government of India has allowed automatic approval for 74 % direct foreign investment in solar photovoltaic technology. General conditions laid down by the Ministry of Industry, Secretariat for Industrial Approvals and the Reserve Bank of India for setting up an industrial undertaking are applicable for this sector. It is possible to set up industrial units as 100 % Export Oriented Unit or under Electronic Technology Hardware Park schemes.

Financial incentives

A package of subsidy and soft loan is available for manufacturers and users of PV products.

Duties and taxes

Concessional duty import of raw materials, components, solar cells, PV modules and systems is permitted. Most of the PV products are exempted from Excise duty. In addition, 100% depreciation benefit is also available

Export oriented units

It is possible to set up a manufacturing plant as a 100% Export Oriented Unit. Generally the export-oriented units are permitted duty free import of raw materials and components. They are also eligible to sell upto 20% of their production in the domestic markets.

Financial Incentives for Solar Photovoltaic Systems

a. Subsidy rate

Sl. No.	**SPV system**	**Central subsidy**
1.	Solar lantern	Rs 1050/- (fixed)
2	Home lighting system/solar home system	Rs 6000/- or 50% of ex-works cost, which ever is less
3	Street lighting system	Rs 12,000 or 50% of ex-works cost, which ever is less
4	Power plants and other systems	Rs 2,00,000/kWp of PV array capacity or 50% of ex-works cost, whichever is less
5	PV water pumping systems	Rs 125 per Wp or PV array used, subject to a maximum of Rs 2,50,000 per system

b. Beneficiaries

SPV System	**Eligible Category Beneficiaries**
Solar lanterns	All categories of individual beneficiaries and non-profit institutions/organisations. No individual would be given more than one solar lantern
Home lighting systems/ Solar home systems	All categories of individual beneficiaries and non-profit institutions/organisations No individual would be given more than one solar lighting system
Street lighting systems	All categories of Non-commercial institutions/organisations, state nodal agencies, electricity boards, panchayats, zila parishads, and DRDAs.
SPV power plants/other systems	All categories of non-commercial institutions/organisations, state nodal agencies, electricity boards, panchayats, zila parishads, and DRDAs.
PV water pumping systems	All categories of users

C. Wind Energy Program

India is the world's fifth largest investor in wind power and the largest wind power producer in developing countries with 1080 MW of installed wind power capacity as on September, 1999.

The first systematic efforts to harness wind energy in the country were undertaken during the late fifties and early sixties by the Council of Scientific and Industrial Research (CSIR) at the National Aeronautical Laboratory (NAL), mainly in the area of water pumping windmills. However, owing to limited interest and relevance in the energy scene then, this work was closed down in 1966. The oil crisis of 1973 revived interest in the country, and in the National Science and Technology Plan specific recommendations were made on harnessing of renewable sources of energy, including wind energy.

During the Sixth five-year Plan (1980-85) focus was mainly on the development and demonstration of water pumping windmill technology. Renewable energy programme started in right earnest only with the establishment of the Department of non-conventional energy sources (DNES) in the Ministry of Power in 1982. Up to the mid-eighties work in this area continued to be concentrated on water pumping and stand alone wind electric generators. A wind energy data handbook was published in 1983 based on an analysis of information and data on wind available from the vast network of meteorological observatories. This served as a preliminary data source for the early initiatives in India during the Seventh five-year Plan (1985-90). Later, an extensive wind resource programme was initiated through the Field Research Unit (FRU), Bangalore of the Indian Institute of Tropical Meteorology (IITM) in 1985. This comprised of wind monitoring, wind mapping and complex terrain projects. The programme is today one of the world's largest wind resource assessment effort covering 600 stations.

During the last fifteen years (1985-2000), the development of wind power in India went through three distinct phases, each marked by a paradigm shift in the policy and implementation frameworks. These are briefly brought out in the following paragraphs.

Demonstration projects (1980 onwards)

Grid connected wind electricity generation, more famous as wind farms, started with setting up of demonstration programme of about 25 MW of aggregate capacity during the Seventh five-year Plan period (1985-90). Wind farms initiated during the 1985-86 year aggregated to an installation of about 3.3 MW capacity wind farms. During the same time the Danish International Development Co-operation Agency (DANIDA) was the first international agency to show interest in the potential Indian wind power market, enabling the Danish manufacturer Micon to be the first to install wind power in India. In 1986 through a joint venture with Natural Energy Processing Company (NEPC) a 1.1 MW demonstration wind project was set-up. Since then, a considerable level of interest was shown by international manufacturers of wind turbines, keen to gain a share of the large potential market for wind power in India.

Indigenisation & private investments (1990 onwards)

The creation of a separate financial institution by the name of Indian renewable energy development agency (IREDA), in 1987 played a key role in facilitating renewable energy project implementation by offering loans on soft terms to users and manufacturers. The demonstration projects of grid connected wind electric generation started with more vigor, and efforts were being made to implement projects with higher rating (150 kW), than earlier ones of 50-100 kW.

One of the major objectives of the government through demonstration programme was to create conditions for the demand for such machines to grow so that indigenous industry could develop. Foreign wind electric generator (WEG) manufacturers started showing interest for collaborating with Indian companies for local manufacturing. Government on its part had devised an Import Policy allowing duty-free imports of WEGs. A private power policy for wind was also announced. However, no private sector investment in wind power occurred largely because investors were unsure of the economic response of the utilities, which were in poor financial health.

Institutional reforms, re-structuring and commercialisation (1992 onwards)

During the early nineties, it was realized that faster diffusion of renewable energy sources required greater reliance on commercialization through fiscal rather than financial incentives involving the private sector - the role of the DNES had to change from a implementing organization to one facilitating the rapid commercial application of renewables. Partly as a result of this, the DNES was converted into a full-fledged Ministry (Ministry of Non-conventional Energy Sources, or MNES) in July 1992. After the formation of the Ministry, thrust of the programs has been on market development in order to facilitate and catalyze commercialization resulting in several-fold increase in the diffusion of renewable energy technologies. India is probably the only country in the world with an independent Ministry for the promotion of renewable energy technologies (RETs) in the energy economy of the country.

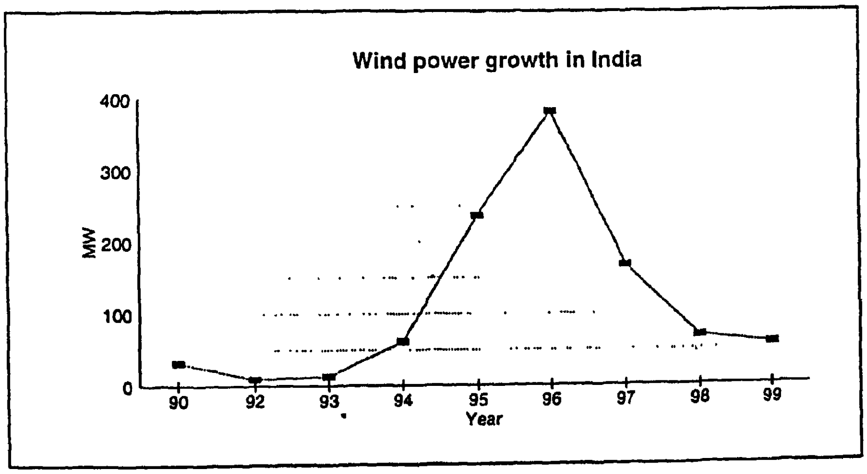
In 1992, the MNES issued guidelines for electricity buy-back tariffs and banking. Some of the state government also came out with incentives linked to sales tax benefits for corporates in the state. This set of investments, became the prime driver for investment in the post-1993 period.

Incentives for wind energy investors

- 100% accelerated depreciation on the equipment
- Concessional finance from Indian Renewable Energy Development Agency (IREDA) (2% less than the commercial terms, with an extended pay-back time)
- Attractive buy-back rates, wheeling, & banking
- Third-party sales and sales tax exemption in some of the states

The spurt in private sector participation in wind energy sector started in 1992, after announcement of the "Private Power Policy" of 1991 and the availability of range of incentives by the government.

After a period of explosive growth that made India the world's third largest (at, present fifth) producer of wind power, investment fell sharply from mid-1996, the possible reasons being as follows



Lowering of tax-credit benefits due to levying of MAT (minimum alternate tax) and lowering of corporate income tax by the Union Government in 1995/96 and 1996/97 respectively, which reduced the attractiveness of wind as a tax-management option

- Withdrawal of third-party sale in some states
- Low CF (Capacity factor/plant load factor) achieved by wind turbines

Some other indirect causes are as follows:

- Negligible foreign investments in Indian wind energy projects
- Higher interest rates

D. Small Hydro Power Programme

Mini-micro hydro power (SHP) is one of the earliest renewable energy sources which has been in existence in the country since the beginning of the 20th century. Even much before that, the technology has been in use in the Himalayan villages in the form of water wheels to provide motive power to run grinders, etc. SHP technology was introduced in India shortly after the commissioning of the world's first hydro-electric installation at Appleton, USA in 1882. The 130 kW plant at Darjeeling in the year 1897 was the first SHP installation in the country. A few other power houses belonging to that period such as Shivasundaram in Mysore (2 MW, 1902), Galgoi in Mussorie (3 MW, 1907), and Chaba (1.75 MW, 1914) and Jubbal (50 kW, 1930) near Shimla are the SHP stations reported to be still functioning properly.

Most of these powerhouses utilized the high head available at the sites. Impulse turbines were generally preferred in such conditions. Initially, the development of SHP was restricted to small hilly streams in the Himalayan region where alternative sources of power were not available. Later, between 1930 and 1950, some low head SHP installations came up on a number of canals on Ganga. The major impediment for SHP stations in early days was that the technology of high voltage transmission lines had not developed, which resulted in heavy line losses wherever the load centres were at long distances.

The development of hydropower in the country was stepped up only after independence, by which time, the technology for large hydro was available and efforts of all state governments/SEBs were mainly on the large multipurpose projects. During the earlier five-year plans, though rural electrification was given priority, no comprehensive plans for development of SHP were drawn up. It was only during the *Eighth Five-Year Plan*, that the Ministry of Non-conventional Energy Sources (MNES) proposed that the status of SHP be upgraded and additional funds be allocated for this purpose. The total installed capacity of SHP projects in India is 155.38 MW and another 208 MW is under construction (MNES 1998).

Classification of SHP systems

All over the world, as well as in India, the hydro is classified by power output. These norms vary country-wise. In India, a hydro power plant of less than 15 MW capacity is termed as small hydro. The Central Electricity Authority (CEA) further classifies the small hydro schemes as follows:

Classification on the basis of size

Size	*Unit size*	*Installation*
Micro	up to 100 kW	100 kW
Mini	101 to 1000 kW	2000 kW
Small	1001 to 6000 kW	15,000 kW

Classification on the basis of head

Ultra low Head	Below 3 meters
Medium Head	Between 30 to 75 meters
High Head	Above 75 meters

Watermills

Gharat, panchakki, ghatta, rantak, chutakh, water wheel - these are the various names of one of the oldest mechanical energy extraction devices popular in the Himalayan region. The watermills, found in almost all the states in the upper reaches of Himalayas, are being used for rural small-scale agro-processing since centuries. In absence of a proper census of this sector, some experts have estimated that about 200,000 of these devices are present in the region. One of the components in the UNDP-GEF Hilly Hydro Project envisages upgradation of 100 of these devices in the region. The idea is to increase the efficiency of thee machines (from present 15% to more than 50%), so as to utilize them for higher end machines like oil expeller, rice huller as well as electricity generation.

Agencies for SHP development in India

Till early 1989, all activities pertaining to the development of SHP were under the administrative control of the Ministry of Power and Central Electricity Authority (CEA), with the responsibility of execution and maintenance with the State Electricity Boards (SEBs). Later, for a comprehensive developmental effort for SHP, the work relating to administrative and policy matters up to 3 MW capacity was transferred to MNES (then DNES) in 1989. Since then, major efforts have been made by the Ministry to encourage SHP projects. Many new approaches viz., standardization, adoption of canal or cluster approach, careful planning of civil works, increasing available head by combining adjoining drops etc. have been adopted to reduce costs and speed up the SHP development. The states have been given the flexibility to introduce suitable policies for private sector participation in setting up of SHP projects. MNES has also evolved a package of incentives and subsidies for the development of SHP sector, with special emphasis on mini/micro hydel projects in remote hilly regions of the country. The above efforts have given rise to a clearly laid out programme for the promotion of SHP in the country.

Indian Renewable Energy Development Agency (IREDA), the financing arm of MNES, is operating a World Bank line of credit to the tune of US $ 70 million to promote private sector participation in the development of small hydro on irrigation canal based sites. Till now about 32 hydro projects aggregating to 180.4 MW have been financed under this scheme of which 21.45 MW is being generated from 8 operational power plants. Similarly, the world's first GEF (Global Environment Facility) project with an outlay of US $ 15 million has been operationalized through the MNES and the UNDP (United National Development Programme). This technical assistance project focuses on the 13 Himalayan states in the country and aims at checking deforestation trends in this ecologically fragile region by demonstrating the use of small hydro energy for lighting, heating, cooking, irrigation, and small industry. Under this project 20 demonstration projects of less than 3 MW and 100 watermills would be installed in the 13 states, covering various social and technical aspects namely, geography, people, end-use, head, flow, total power generated etc. The ultimate goal of the project is to prepare a national strategy and subsequently a master plan for the development of small hydel projects in the entire Himalayan region, based on the experience of the demonstration projects.

Government policy for SHP development

The power generation policy for the private sector was declared in 1991 by the Government of India. The respective State Governments are responsible for development of water and power resources in each state. The MNES provides the guidelines and initiatives.

The capital subsidy @25% of the project cost (project at the cost of Rs 60000/kW) is now provided only for projects with an installed capacity of less than 50 kW in the North-eastern region. The capital subsidy for projects up to 3 MW in the hilly areas, North-eastern region, and A & N Islands is to the tune of 5% of interest subsidy on the loan component of 60% of project cost, or Rs 36000/kW (whichever is lower with the minimum floor rate of interest as 10%). For other areas, 2.5% of interest subsidy with minimum floor interest rate as 12.5%. The MNES has also launched a scheme for lightweight, portable sets in the range of 5, 10, 15 kW where it has already distributed 50 sets free of cost to NGOs/societies through state nodal agencies. The IREDA provides loans for projects up to 15 MW capacity, as 75% cost of projects for E&M works at 12.5% interest rate.

In addition, several (12) states have announced policies for private sector participation. Wheeling of power is charged at 2-2.5%, with exception of one or two states charging even up to 15%. 100% depreciation on the capital cost of small hydro, in the first year, is yet to be allowed by the Central Government, though the matter is under consideration.

SHP policies of the Government

S.No	Programme/scheme	Amount of subsidy	Type of subsidy	Implementing agencies organisations/beneficiaries	Channel of funds
a	Capital subsidy for Small Hydro Project upto 3 mw station capacity	Upto Rs 3 crores mw or 50% of the cost the project whichever is lower	Capital subsidy	Projects executed by SNA, state govt., Power dept., SEBs in the north east	Subsidy is released directly to state Govt. SNA
b	Capital subsidy for Small Hydro Project upto 100 kW capacity	@ Rs 15000/ per kW	Capital subsidy	Proposals executed by State Nodal agencies/ State Government Dept. / NGOs/ local bodies in Hilly Regions and Andaman & Nicobar islands; and by Ngos, Local Bodies, in the North Eastern Region	Directly to concerned Executing Agencies
c	Interest subsidy for small hydro power project upto 3 mw	Capitalised amount of upto Rs 1.12	Interest subsidy	Private Sector, Cooperative Sector, NGOs, Local	Subsidy released through

E. Rural Energy Programs

70% of the population in India, over 650 million, still live in the rural areas. Traditional biomass resources still meet an overwhelming proportion of the rural energy demand. One of the main reasons of this continued dependence on biomass is the failure of the commercial fuels such as kerosene and LPG to penetrate the rural areas on account of high costs and low accessibility. On the other hand, inefficient use of biomass in traditional devices has serious environmental effects both at local and global level. In the past two decades, there have been several attempts by way of promoting various renewable energy programs, forestry programs, etc. but their impact has been significant enough neither to make a dent on the growing energy demand in the rural areas nor to mitigate the adverse environmental effects.

Intervention programs

Though there has never been a single, overarching rural energy policy for the country, the government, through it various committees such as Fuel Policy Committee (1974), Working Group on Energy Policy (1979), Advisory Board on Energy (1985), Energy Demand Screening Group (1986), etc. has formulated programs aimed at rural energy and implemented through various ministries. Initially the major thrust was on fuel substitution by supplying kerosene through the Public Distribution System and power through rural electrification. A number of afforestation schemes such as wasteland development and social forestry have also been promoted for augmenting the supply. And finally, a number of renewable energy programs such as biogas, improved cookstoves, etc. have been implemented. Some of these programs are discussed here.

Rural electrification

This is the largest of the rural energy programs, launched in 1952 with the aim of reaching electricity to all the villages. In order to give a specific thrust to the programme, a separate organisation, the Rural Electrification Corporation (REC), was established in 1969 to implement the programme. By the end of 1993-94, more than 85% of the 580,000 villages in the country have been reportedly electrified, and over 10 million pumps energised (CEA 1996). While this has been an impressive achievement, the number of households having electricity connections is still quite low, only about 30% (Gupta 1996).

One of the major reasons for this is the inaffordability on the part of the majority people to avail the benefit (installing a meter in the household is expensive). In order to deal with the cost constraints, various state electricity boards (SEBs) have launched 'kutir jyoti' scheme in which single point (one bulb) connections were provided to economically weaker households4. However, the quality of supply has also not been consistent due to long transmission and distribution5.

Energisation of pumpsets for irrigation has gone at a brisk pace crossing 10 million out of a total estimated potential of 14.5 million pumpsets, but there are still a large number waiting to get electric connections (in Tamil Nadu, for instance, there is a waiting list of nearly 500,000 farmers). But even more serious problem in this sector is the heavy subsidy on electricity given to farmers (in most states, the tariff is negligible and not more than half a rupee per unit). In many cases, the bill collection system (due to the diffused nature of the

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4Details in terms of total achievements, success, etc. are not available. This scheme remains the only effort to reach electricity to the poor.

5The T&D losses due to technical reasons, pilferage, etc. are estimated to be 23% of total power generation in India (TERI 1995a).

sector) is expensive and cumbersome. Given the fact that the tariff is extremely low, electricity is consumed in an inefficient and wasteful manner. Because of this, several State Electricity Boards (SEBs) have been incurring huge losses. Also, price of agriculture power tariff has become a major political issue with medium and rich farmers representing a powerful lobby, opposing any move to rationalise the pricing structure. And since the power sector is a concurrent subject handled by the central as well as state governments, the SEBs have the responsibility of supply and distribution, but no control on the policy making including pricing.

One of the major issues in this regard is that, so far, rural electrification has meant extension of the conventional grid, with little or no emphasis on decentralised electrification and harnessing of renewable energy sources. Because of this, the remote and inaccessible villages in several parts of the country, where grid extension is viable neither logistically nor economically, have not been able to benefit from rural electrification. It is estimated that about 87,000 villages are still in this category and a majority of them are not likely to have grid electricity ever.

Forestry programs

There have been a number of programs in the form of wasteland development and social forestry by various state governments and many of the projects were supported by multilateral agencies like the World Bank and the Ford Foundation. However, none of these programs has been exclusively targeted to augment fuelwood supply, and in many cases they have been commercial (e.g. Eucalyptus). Thus the choice of species has been a major issue with these programs.

Given the fact that demand for fuel is growing constantly, enhancement of supply through afforestation will remain a major option. However, the major constraint would be to identify common lands for the purpose. In India, though area under wastelands and other public lands is high as per records, actually most of this land would be under some productive use. Acute pressure of growing population leads to demand for greater cultivable land, and hence all types of lands are put to some use irrespective of the quality[6].

Another impediment in this regard has been lack of adequate seed and sapling material to be used in afforestation, particularly relevant for fuelwood tree species. Seed development programs for the purpose are yet to be taken up in the country on a large scale.

People's participation, one of the major objectives of afforestation programs, has also remained largely unfulfilled as effective local institutions to facilitate this are yet to be developed in a big way. A positive beginning has been made with the Joint Forest Management (JFM) projects in Haryana, West Bengal, Karnataka, etc. where attempts were made to involve local people along with the forest department officials in managing the forest resources in a sustainable manner (Panda, et al 1992)[7]. However, energy development activities are yet to be part of this process.

Renewable energy programs

India has one of the largest and most active renewable energy programs in the world, a significant part of which is directed towards rural energy requirements. Most renewable energy technologies (RETs) are environmentally benign and make the most optimal use of locally available natural resources whether it is sunlight, wind, water or biomass.

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[6] It is estimated that there are 50 to 70 million hectares categorised as wastelands in the country.

[7] In the Shivalik region of Haryana, there are 56 village-level Hill Resource Management Societies (HRMS) operating under JFM. The local people and forest officials are members of these societies who have jointly devised ways of preserving forests, harvesting rain water for irrigation, income generation through basket weaving, etc.

Institutional aspects of rural energy

The main feature of the institutional structure in the rural energy sector is the multiplicity of organisations involved in different programs at various levels. There are several ministries and apex bodies formulating policies and monitoring the progress of individual programs. Also, the Planning Commission is involved in these exercises in order to allocate annual budgets for specific programs. Then there are nodal agencies at the state level which implement the programs through district level bodies (e.g. District Rural Development Agency) and block level bodies (e.g. Block Development Office). In addition, there are a host of non-governmental organisations, research/academic institutions, etc. who are involved in the programs in various capacities. However, there is very little for the lower level bodies in the policy formulation.

The state level nodal agencies (and in some cases, the state departments) are responsible for the implementation of various programs. For most of the programs, the finances are provided by the central government with the state governments taking care of the establishment costs8. In that sense, state nodal agencies are dependent on the Centre for their existence.

A 'top-down' approach is adopted in the implementation of programs. The physical targets are set at the central level which are then transmitted to various levels below, and often these targets are determined independent of actual requirements. The lower level bodies are supposed to send quarterly progress reports to the respective higher agencies, but there is no effective mechanism is in place that this reporting is regular and the feedback is acted upon. The rural people, the ultimate beneficiaries of the programs, have little role in deciding the design and content of any rural energy programme. In fact, several evaluation studies point out that target-orientation as one of the major causes for the programme failures.

F. Biomass Power / Cogeneration

The National Programme on Biomass Power / Cogeneration is aimed at establishing techno-commercial feasibility and viability of power generation from biomass materials which are either wasted or sub-optimally utilised. To make the programme more effective its various provisions were revised during 1999-2000. The eligibility, support structure, and pattern of financial incentives under the programme are given below:

8Apart from the funds provided for subsidies, training, awareness creation, technical back-up, etc. for specific programmes (NPBD, NPIC, IREP, Urjagram), MNES also pays service charges to the nodal agencies depending on the targets. For instance, if the yearly target for biogas plants is over 20,000, the nodal agency receives Rs 2.15 million plus Rs 50 per every plant in excess.

One of the major barriers in promoting RETs has been their high initial cost. In order to offset these, most programs were given direct state subsidies. The government set targets for various programs every year that were implemented through the state nodal agencies and their lower bodies. However, the overall strategy to promote RETs underwent a change in late 1992, in line with the economic liberalisation process launched in the country. Now the major thrust was shifted to commercialisation of RETs and promotion through market orientation. Subsidies were withdrawn in most cases, and soft loans were provided through the Indian Renewable Energy Development Agency (IREDA), a financial institution created by the MNES. A package of fiscal and monetary incentives was also put in operation by the government. However, direct subsidies still continue in the case of many rural energy programs.

The National Project on Biogas Development (NPBD) is traditionally the largest rural energy programme of the MNES in terms of investment, but the National Programme for Improved Chulhas (NPIC) is the largest in terms of reach. The rest of the programs are still in the initial stage of dissemination and their penetration is not significant. On the other hand, the major rural renewable energy programs continue to be run on similar lines as earlier, though there is now more emphasis to have increased involvement of the rural entrepreneurs and non-governmental organisations.

In the last 15 years of their existence, the rural renewable energy programs have had several successes as well as failures. However, the overall impact of the renewable energy programs has been miniscule compared to the overall magnitude of the rural energy requirement.

Area-based rural energy programs

Apart from the technology-based programs, the government has also been promoting some area-based programs. The most prominent among them is the Integrated Rural Energy Planning Programme (IREP), which was earlier implemented by the Planning Commission but subsequently transferred to the MNES. IREP envisages energy planning at the block level, and 860 blocks have already been covered by December 1998. The other major programme is the Urjagram, run by the MNES, which aims to make individual villages self-sufficient in their energy needs by using a combination of renewable energy technologies. In addition, more than 1000 large-sized community biogas plants were set up to cater to clusters of families, at the village level. However, most of these systems did not succeed due to lack of community involvement (Moulik, et al 1983; Ramana 1991a).

Financial allocations for renewable energy sector

One of the main reasons -- apart from other reasons such as high initial costs, shortcomings in implementation methods, limited number of mature technologies, etc. -- for low penetration of renewable energy technologies has been the low level of investment made by the government in the sector. For instance, between 1981 and 1992, the government expenditure on grid electricity was Rs 812 billion; Rs 335 billion on petroleum; and Rs 158.5 billion on coal. Compared to this, the investment in renewable energy was a meagre Rs 11.55 billion. This low priority was reflected in the VIII Five Year Plan (1992-97) allocation, too, with renewable energy having a share of just 0.8% (GOI 1992). Of the VIII Plan allocation of Rs 8.57 billion for the renewables, almost 50% would be spent on biogas and improved chulha programs, a major part of which would be in the form of direct subsidies. However, the budget allocation for these programs in the last two years has not increased in real terms as attempts are being made to rationalise the subsidy patterns, and to involve local entrepreneurs in the implementation process.

Power from biomass: eligibility and support structure

Resource base	BIOMASS (Stalk, Straw, Husk, Fines of biomass origin, Agro-processing residues, etc.) BAGASSE
Technology base	Any technology route, appropriate and efficient for conversion to power; Gas/steam turbine, dual fuel engine / gas engine route involving pyrolysis, gasification incineration with / without intermediate pellestisation / briquetting; or a combination thereof
Application Base	COGENERATION (Steam and Power) or POWER
Capacity Base	Min 1 MW surplus; grid interfaced
Financing Base	All FI s/Industrial Development / Investment Corporations; All Nationalised Banks and State / Public Sector Leasing and Financial Corporations severally or in consortia
Implementing Arrangements	Through State Govt. / State Nodal Agencies and FI s
Eligible Promoters	Promoters, individuals or in consortia with other promoters; Public Sector institutions; voluntary agencies; Registered Industry Associations; Registered Companies; Joint Venture Company and State Nodal Agencies; BOOT, BOT, BOLT, BOOM, BOO basis or IPP Mode

Source: MNES Annual report 1999-2000

Incentives

The following incentives are provided to promote biomass power projects:

(a) Interest subsidy is provided for biomass power projects (commercial projects) subject to net rate of interest, after the interest subsidy, not being less than 11% per annum as detailed below

Category	Reduction of Interest Rate on Term Loan
Forestry based and Agro-based Industrial residues	2%
Energy Plantation; Forestry and Agro Residues	3%

(b) Interest subsidy is available for bagasse / biomass cogeneration projects (commercial projects), subject to the net rate of interest, after the interest subsidy, not being less than 11%. The details are as follows:

Configuration	Reduction of Interest Rate on Term Loan
40 bar and above	1%
60 bar and above	2%
80 bar and above	3%

(c) Capital subsidy is provided for cogeneration projects in cooperative / public sector sugar mills through joint venture (JV) companies to be set-up by State Governments or IPPs – for JV companies in only four states and to four IPP projects, on "first come, first served" basis. The details are given below

Demonstration projects	**Minimum exportable power**	**Minimum configuration**	**Capital Subsidy (Interest subsidy not applicable)**
In Group of Mills; through Joint Venture Company (JVC), set-up by the State Government / Agency, with a fresh equity contribution [of not less than Rs. 10 lakh / MW of surplus power] in the JVC	45 MW	60 bar & above	Rs 35 lakh / MW of surplus power (Max Rs 31.50 crore / project)
		80 bar & above	Rs 45 lakh / MW of surplus power (Max Rs 40.50 crore / project)
Single Mill, through IPP Mode	9 MW	60 bar & above	Rs 35 lakh / MW of surplus power (Max Rs 6.30 crore / project)
		80 bar & above	Rs 45 lakh / MW of surplus power (Max Rs 8.10 crore / project)

(d) The other incentives available for biomass power / cogeneration projects are given below

To	**Biomass Power / Cogeneration Projects**
State Nodal Agencies	Rs 0.50 lakh / project; Max. 10.00 lakh
Detailed Project Report	50% Max. Rs. 5.00 lakh depending on boiler pressure
Consultancy Firms	Rs. 2.5 lakh / Project (Max)
Biomass Banks / Depots	Interest Subsidy @ 5% (max)

(e) Financial assistance is available to the State Nodal Agencies for biomass resource assessment (NBRA) studies up to 90% of the cost, or Rs. 1.50 lakh per study, whichever is lower

Progress and status

MNES has taken a number of steps to create widespread awareness and promotion of the acceptance of biomass power / cogeneration. During 1999-2000, the achievement has already exceeded the physical target of 40 MW fixed for the year with the commissioning of 5 projects with an aggregate capacity of 51 MW in four States. Another 3 projects in three states, aggregating 20 MW are likely to be commissioned by the end of March 2000. In addition, 13 projects spread over seven States, aggregating 130 MW surplus / exportable capacity, are in advanced stages of planning. Besides these, 26 projects aggregating 200 MW may be in the pipeline.

One of the most significant achievements has been the adoption and increasing acceptance of the technology configuration of 40 bar and above, as against the lower configuration adopted hitherto for cogeneration. The modified programme endeavors to promote adoption of even higher pressure / technology configurations of 60 bar and above by offering additional incentives in the form of interest subsidy in a graded manner linked with higher technology configurations. The scheduled and nationalised banks, as well as the State and public sector leasing and financial institutions, have also started evincing interest in financing such projects.

As a result of the momentum generated, a capacity of 222 MW of surplus power has already been commissioned while projects with a total capacity of 280 MW are under construction.

New initiatives

A Lead Programme Partnership Initiative has been launched for facilitating commercial biomass power / cogeneration projects. About 50 projects aggregating about 500 MW spread over nine major sugar producing States have so far been identified. This initiative has facilitated the promotion of projects leading to financial closure, particularly by cooperative / public sector sugar mills. Sustained measures to ensure coordination and follow-up with the Ministry, financial institutions, State agencies, State Electricity Boards on the one hand and with promoters and sugar mills on the other are being undertaken by the programme partners. It is proposed to expand this initiative to cover all other areas of biomass power / cogeneration such as paper, rice milling, cotton, tea processing and coconut industries.

JV/IPP Model for Co-operative & Public Sector Sugar Mills

The Government of Tamil Nadu has approved the establishment of a joint venture company with Rs. 8.2 crore as its share of equity for cogeneration projects in a group of 9 cooperative and one public sector sugar mills with an aggregate capacity of 82 MW of exportable power. Such joint venture companies set up by the State Governments have been made eligible for capital subsidy under the Ministry's National Programme on Biomass Power / Cogeneration. The Governments of Andhra Pradesh, Haryana, Maharashtra, Punjab, Uttar Pradesh and Gujarat have also shown interest in following a similar approach to promote cogeneration in their cooperative / public sector sugar mills.

UNDP-GEF Assistance

A Preparatory Assistance (PA) Mission had initiated work for developing a full project document on "India Biomass Power Generation Project" for GEF funding. A project brief detailing the objectives, outputs, activities, budget and duration as per the GEF project document format has been prepared. The proposal has been posed for assistance to the UNDP-GEF and other bilateral donors / institutions. The implementation of this project is likely to commence during the next year.